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The Journal of The Royal Aeronautical Society

With which is incorporated The Institution of Aeronautical Engineers

Edited for the Council by Capt. J. LAURENCE PRITCHARD, Hon. Fellow

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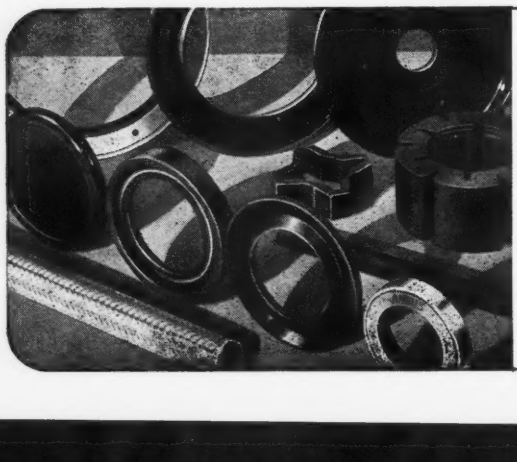

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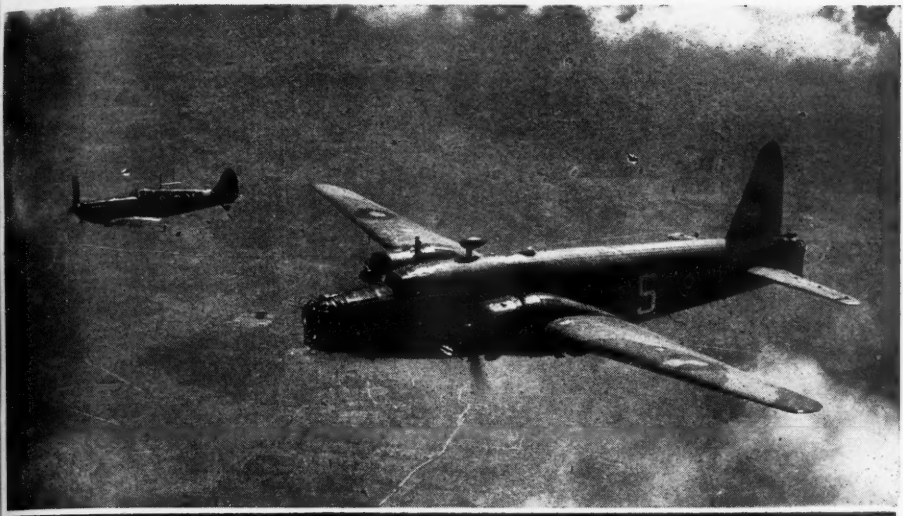

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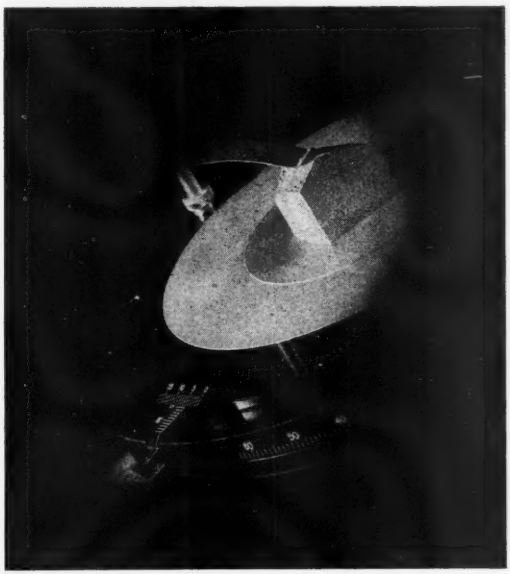
THE illustration shows the mechanical stage of a modern metallurgical micrographic camera, on which is mounted a prepared specimen of MAGNUMINIUM magnesium alloy. The polished surface to be microphotographed is placed face downwards over a variable aperture. The instrument incorporates a source of light, a camera and elaborate optical systems for directing the light on the prepared surface, magnifying up to 1,000 diameters and projecting it upon a photographic plate with further magnification to 3,000 diameters. The stage may be rotated through 360° or translated along its rectangular co-ordinates, the angles of rotation or distances traversed being measured by the graduations shown. This is a further reminder of how the latest discoveries in scientific knowledge and equipment ensures that Magnuminium is kept in the forefront of modern developments in industry's lightest metal.



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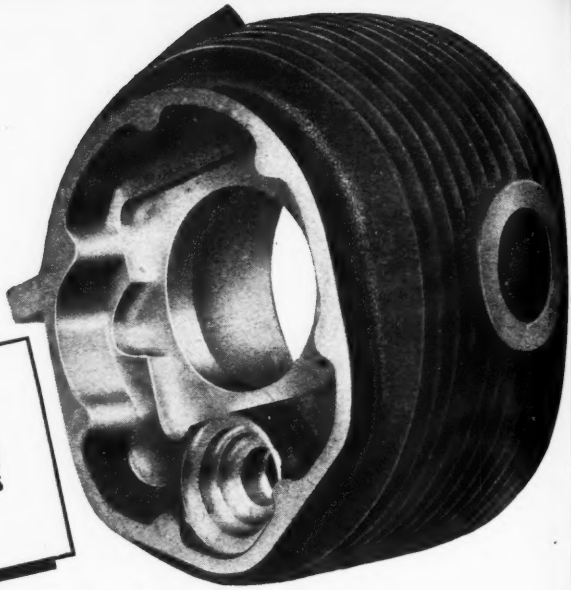

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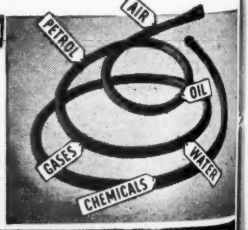

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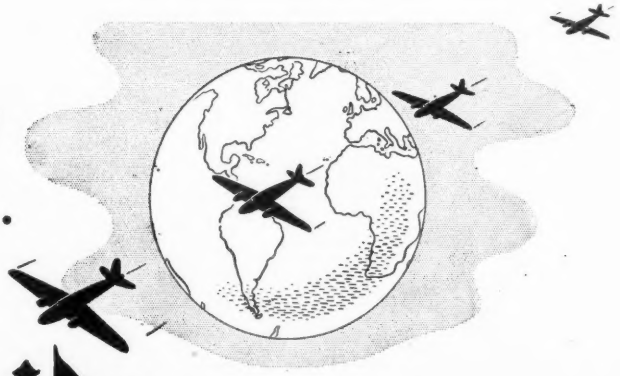

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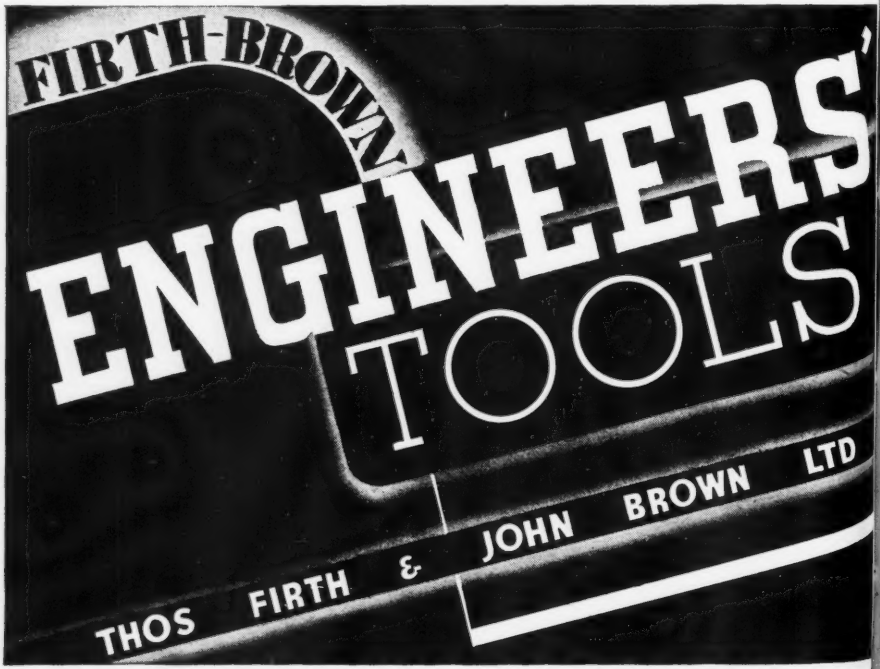
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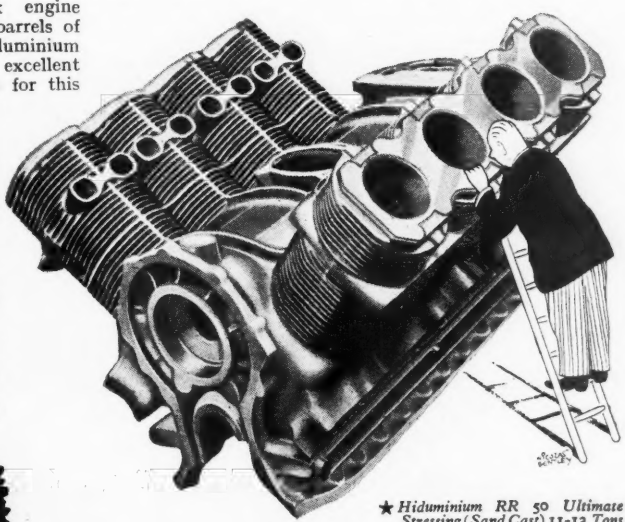

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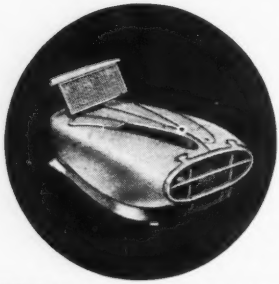

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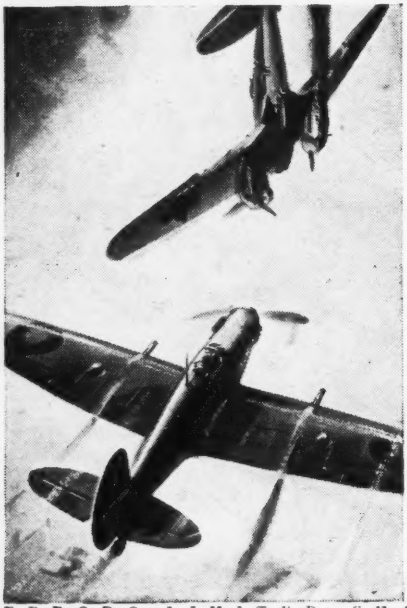

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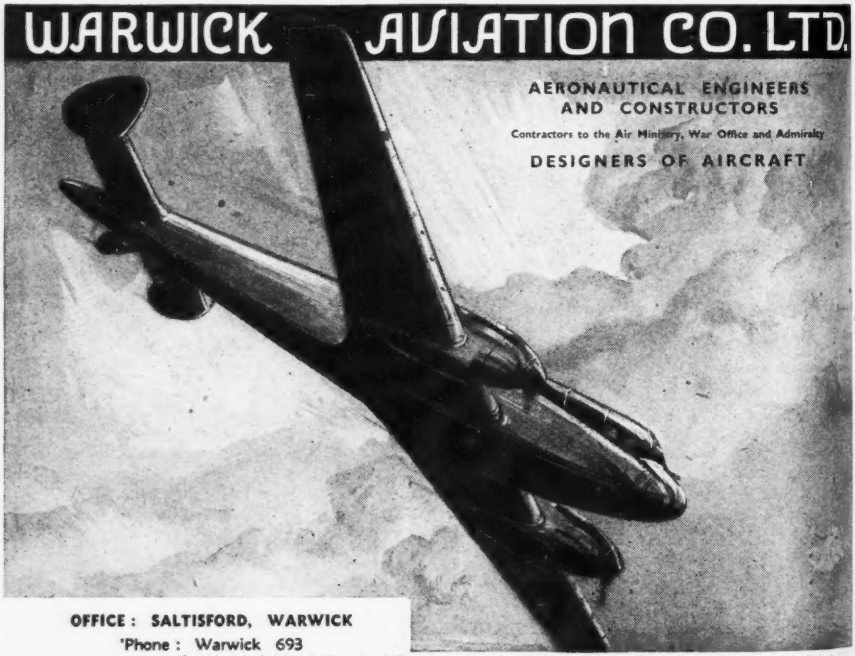

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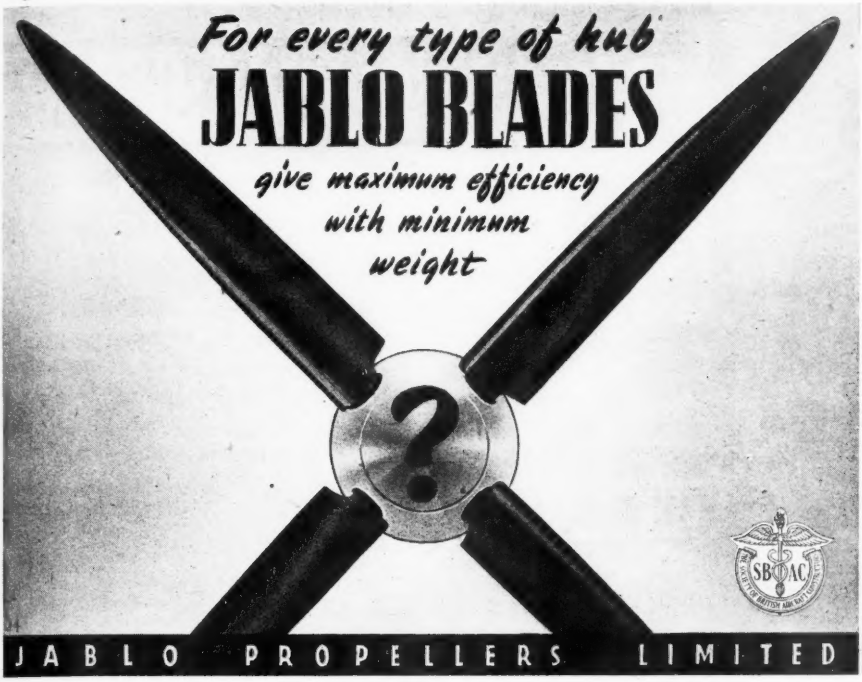
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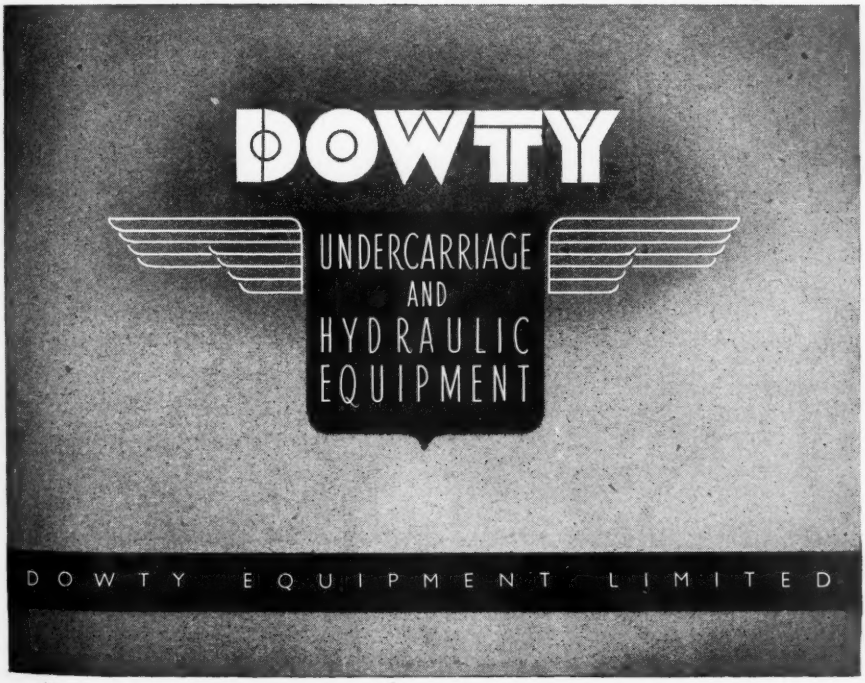
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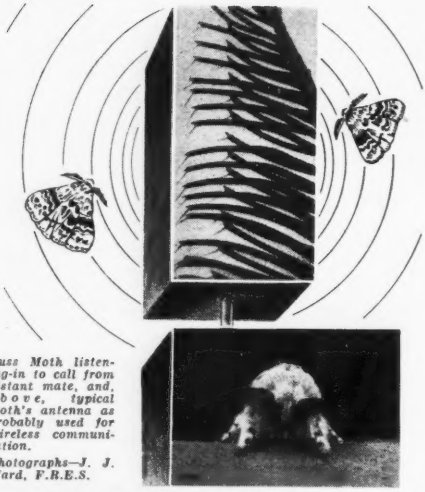

Puss Moth listening-in to call from distant mate, and, above, typical moth's antenna as probably used for wireless communication.

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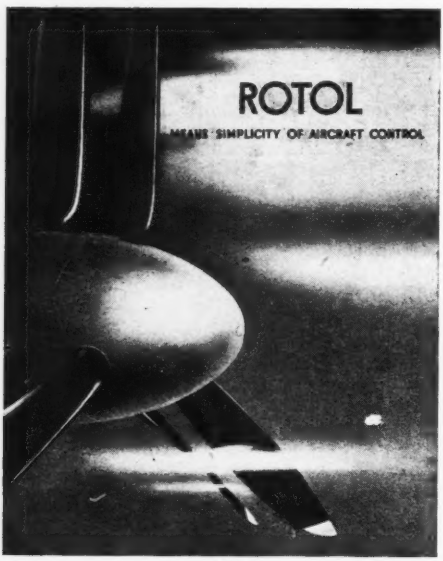

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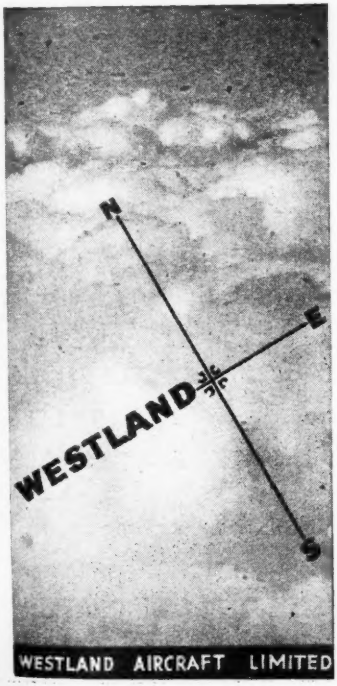

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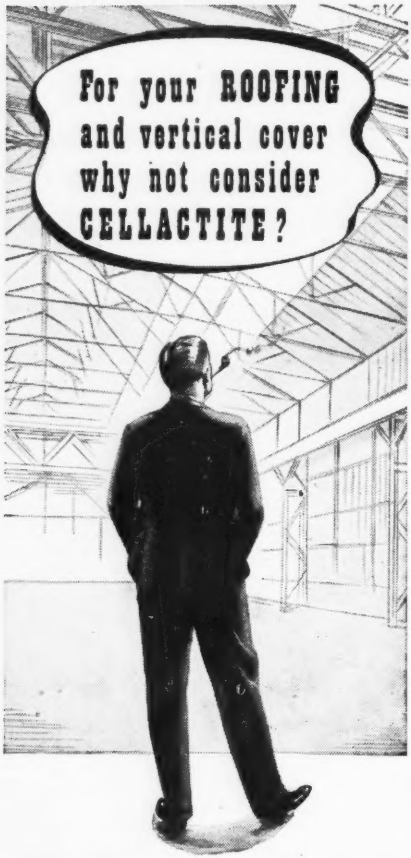

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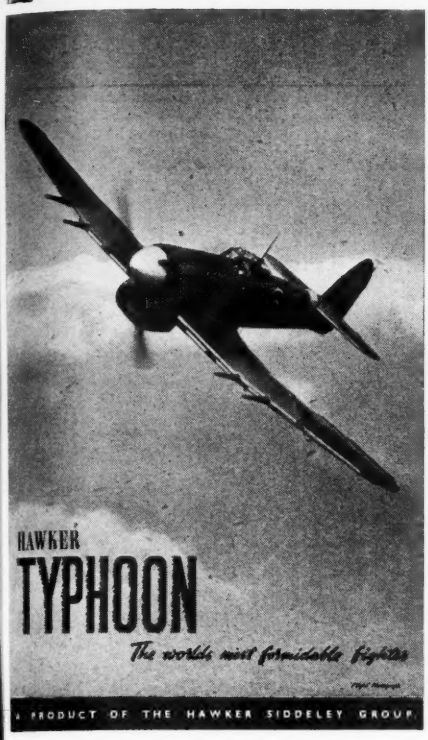

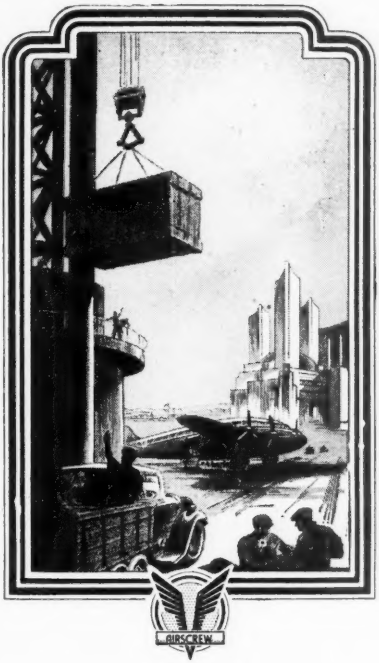

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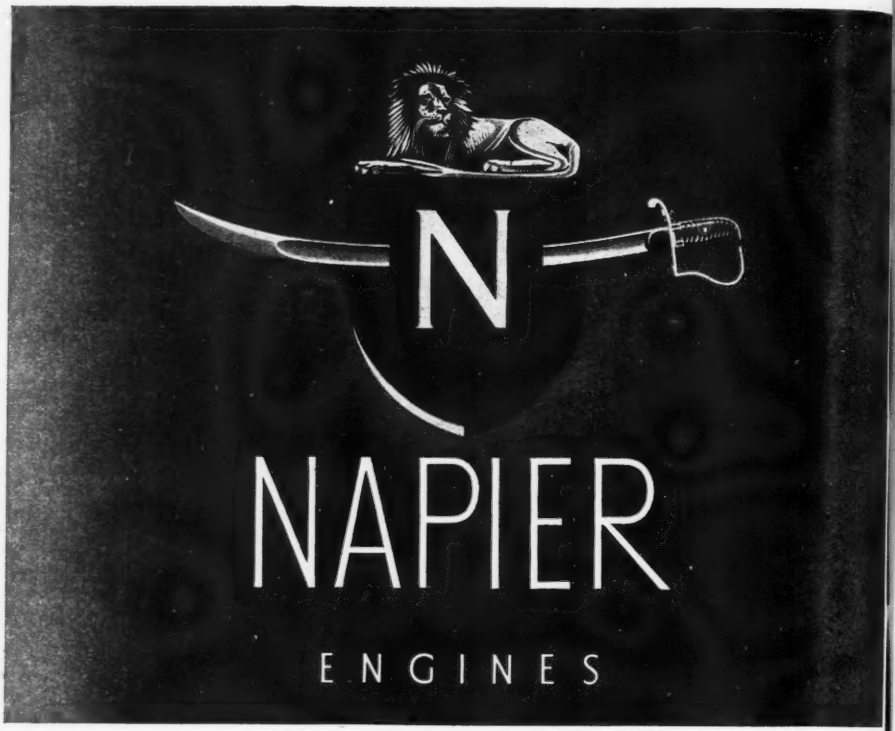

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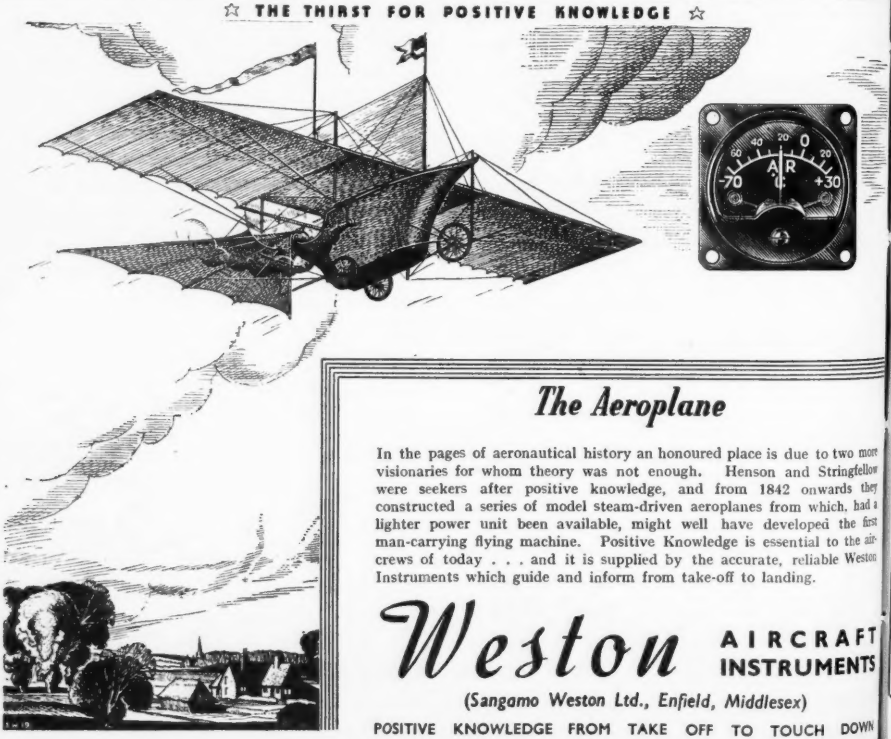

The Aeroplane

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THE JOURNAL OF THE ROYAL AERONAUTICAL SOCIETY *was founded in* 1897 *in succession to the* ANNUAL REPORTS.

For the opinions expressed in Papers that are signed or initialled the authors alone are responsible. None of the papers or paragraphs must be taken as expressing the opinion of the Council of the Royal Aeronautical Society unless such is definitely stated to be the case.

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THE ROYAL AERONAUTICAL SOCIETY

WITH WHICH IS INCORPORATED THE INSTITUTION OF AERONAUTICAL ENGINEERS.

MONTHLY NOTICES

OCTOBER, 1943.

Library Opening.

The Library is normally open on Mondays-Fridays inclusive from 9.30 am.—5 p.m. In addition it will also be open on Saturday afternoons from 2.30 p.m.—5.30 p.m. until further notice and as long as the attendance justifies it.

The Library will remain open on Saturday afternoons for the whole of October, but if the number of members attending does not increase then it is felt the continuation of the arrangement will not be justified.

Subscriptions.

Members are reminded that their 1944 subscriptions will become due on 1st January, 1944.

The Council are very grateful to all those members who have offered to forego their Journals for the duration of the war. The same reductions will be made to the 1944 subscriptions of these members as applied to the 1943 subscriptions. Subscriptions of Fellows, Associate Fellows, Graduates, Companions and Founder Members, who have given up their Journals will therefore be reduced by 10s. 6d. Associates will receive the reduction already laid down in the Rules and the low subscription at present paid by Students does not permit any reduction to be made.

The following will be the rates for 1944 therefore:—

	Home receiving Journal. £ s. d.	Home not receiving Journal. £ s. d.	Abroad receiving Journal. £ s. d.	Abroad not receiving Journal. £ s. d.
Founder Members	2 2 0	1 11 6	2 2 0	1 11 6
Fellows	4 4 0	3 13 6	3 3 0	2 12 6
Associate Fellows	3 3 0	2 12 6	2 2 0	1 11 6
Associates	2 2 0	1 1 0	2 2 0	1 1 0
Graduates (age 21-25) ...	2 2 0	1 11 6	2 2 0	1 11 6
,, (age 26-28) ...	2 12 6	2 2 0	2 12 6	2 2 0
Students	1 1 0	1 1 0	1 1 0	1 1 0
Companions	2 2 0	1 11 6	2 2 0	1 11 6

Election of Members.

The following members have recently been elected:—

Associate Fellows.—Charles Albert Beard, Albert Jeffrey Broadhurst, Michael Golovine, Daniel J. Gribbon, Frank Kenneth Poulton, Donald Howard Wilson.

Associates.—Thomas Albert Victor Booth, Harold Edward Brand, Dennis Gerald Brinjes, John Reginald Bryans (from Companion), Mrs. Ann Courtenay Douglas, Charles Jones, Edward Henry

William Lucas, Alfred William James Norkett, Colin Arthur Richardson, Walter Roy Scott, Cecil Raymund Shepherd, William Eric Thornton-Bryar.

Graduates.—Alan Edgar Foster, Ronald Owen Hender, Jack Hughes, Ronald George Manley (from Student), Hubert Arthur Oxley, Walter Percival Cuthbert Soper.

Students.—Alan Quentin Bell, Roy Cheater, John O. Emmerson, Frank Norman Holdsworth, Ian Hale Lewin, John Italo Orlando, Thomas William Penrice, Robert John Templin, John Prynne Uffen, Kenneth Douglas Wells.

Companions.—John Elliot, Charles Owen Griffiths, Max Karant, Malcolm Rae.

Abstracts.

Members should note that the Abstracts from the Scientific and Technical Press and Titles and References of Articles are printed as a separate section, and are not part of the Journal for binding purposes. This section is numbered for separate binding if members so wish, and a separate index provided in the December Journal.

The Titles and References are published during the war to enable members to keep in touch with information they might not otherwise receive.

Advertisements.

The fact that goods made of raw materials in short supply, owing to war conditions, are advertised in the Journal should not be taken as an indication that they are necessarily available for export.

Acknowledgments.

The Society have received a magnificent copy, in its contemporary binding, from Dr. Poynton, of " A Narrative of the two Aerial Voyages of Doctor Jefferies with Mons. Blanchard," published in 1786.

The first voyage was made on November 30th, 1784, from London into Kent, and the second on January 7th, 1785, when the two balloonists made the first crossing, from England to France, of the English Channel by air.

Additions to the Library.

Pamphlets in italics with location reference following in brackets.
Books marked * or ** may not be taken out on loan.

A.d.26.—*Build Your Own Wind Tunnel.* " *The Aero-Modeller,*" *June,* 1943. (*Photostat.*) (PA.2.c.6.)

E.d.19.—Aircraft Layout and Detail Design. Newton H. Anderson. McGraw Hill Book Co. 1941. 21/-.

EE.c.72.—Elementary Handbook of Aircraft Engines. A. W. Judge. Chapman and Hall. 1943. 12/6.

EE.c.73.—Aircraft Engine Design. Joseph Liston. McGraw Hill Book Co. 1942. 31/6.

G.a.60.—Practical Aircraft Sheet Metal Work. Russ Frazer and Orrin Berthiaume. McGraw Hill Book Co. 1942. 21/-.

*G.b.4.—*British Standards Institution, Specifications*:—
6V.3. High Strength Plywood for Aircraft. 1943. 1/-.

G.e.A.88.—*Fusion Welding of Wrought Aluminium Alloys. Wrought Light Alloys Development Association.* 1943. 1/-. (File Case.)

G.f.30.—Aircraft Riveting. Albert H. Nisita. McGraw Hill Book Co. 1942. 17/6.

I.a.34.—Basic Calculations for R.A.F. Ground Duties (Radio, Wireless and Electrical Trades). A. E. Druett. Sir Isaac Pitman. 1943. 3/6.

J.g.195.—*Meteorology Simplified. Joseph I. Fell. Sir Isaac Pitman.* 1943. 1/-. (PJ.1.b.16.)

L.d.95.—A Handbook of Sea Navigation. W. M. Smart. Longmans, Green and Co. 1943. 7/6.

M.a.27.—Aircraft Electrical Engineering. F. G. Spreadbury. Sir Isaac Pitman. 1943. 21/-.

M.c.64.—Principles of Aeronautical Radio Engineering. P. C. Sandretto. McGraw Hill Book Co. 1942. 24/6.

M.c.65.—Radio Navigation for Pilots. Colin H. McIntosh. McGraw Hill Book Co. 1943. 15/-.

**R.e.51.—Early British Balloon Posts. John Pringle, M.D. (Privately printed; undated.)

R.f.88.—Flying. Claude Grahame-White. Chatto and Windus. 1930.

R.f.89.—*British Aviation. F. A. de V. Robertson. Longmans, Green (for the British Council).* 1940. (PR.3/21.)

S.e.68.—The Sky's the Limit. (Lord Beaverbook at the Ministry of Aircraft Production.) David Farrer. Hutchinson and Co. 1943. 6/-.

T.b.87.—Down Africa's Skyways. Benjamin Bennett. Hutchinson and Co. 1932.

T.b.88.—Great Flights. C. St. John Sprigg. Thos. Nelson and Sons. 1935.

*X.c.R.1.—Grand Dictionnaire Français-Russe et Russe-Français. Th. de Veys-Chabot. Garnier Frères, Paris. 1928.

*UU.c.—*National Advisory Committee for Aeronautics: Technical Memoranda.*

No. 1,046. Experimental Investigation of Impact in Landing on Water. R. L. Kreps. (C.A.H.I. No. 438, 1939.)

*Y.19.—*Ministry of Aircraft Production: D.T.D. Specifications.*

Nos. 62B, 63A, 164A, 166B, 171B, 213A, 227A, 251B, 256C, 279B, 319, 335A, 375C, 417A, 420B, 436A, 438, 448B, 463,473, 480, 484, 485, 488, 492, 498, 501, 503, 504, 507A, 514, 515, 517, 519, 523, 524, 525, 526A, 527, 528, 531, 532, 533, 534, 535, 537, 539, 540, 545, 548, 549, 551, 557, 563, 600, 912, 915A.

J. LAURENCE PRITCHARD, *Secretary and Editor.*

THE EDUCATION AND TRAINING OF AERONAUTICAL ENGINEERS.

The Royal Aeronautical Society held an open meeting in the lecture theatre of the Institution of Mechanical Engineers at Storey's Gate, St. James's Park, Westminster, London, S.W.1, on Friday, June 25th, to discuss the education and training of aeronautical engineers.

In the chair, Dr. H. Roxbee Cox, a Fellow and Vice-President of the Society.

THE CHAIRMAN: The occasion was unusual, because apart from the meetings at which the Wilbur Wright Lectures were delivered—which could never be abandoned, whatever the circumstances—it was the first open meeting of the Society during the war.

They had experienced, and were still experiencing, under war conditions, great difficulty in finding a sufficient number of aeronautical engineers and scientists; whilst it was difficult, if not impossible, to arrange matters now just as they would like them, it was necessary to consider how to ensure later on an adequate supply of people thoroughly trained in all the aspects of aeronautical work.

The educational scheme which it was hoped to evolve would have to embrace the training of men to be designers, engineers and scientists, the training of others to be navigators, pilots and captains, and others to be aircraft engineers or, as they had been called in the past, ground engineers. Thus, the field was extremely wide, and only part of it could be covered in the course of one evening.

Inasmuch as the Society was a scientific and engineering body, the discussion should be concerned primarily with the technical side of the educational scheme; the Chairman drew attention particularly to the education of men who would form the design, development, research and experimental staffs. Technical aeronautics was a highly specialised science, having for its background engineering, mathematics and physics. Therefore, whatever plans were discussed for education of the university level, they should provide for a thorough training in those and allied sciences; and aeronautics should be the subject of specialised post-graduate studies. The Chairman urged most emphatically that in that post-graduate training there should be the closest contact between those destined for design, those destined for research, and those who were to be flying men, whether civil or military. There should be no rigid compartmenting, and each should have a good understanding of the others' problems. Many of our pilots should be engineers, and our engineers should be pilots.

Already a number of suggestions had been made for the development of aeronautical technical education, ranging from proposals for an aeronautical university, at one end of the scale, to the extension of existing arrangements at the other end. Many responsible individuals and groups of individuals had given a great deal of thought to the problem recently. The Chairman suspected that the solution of the problem lay somewhere between the two extremes he had mentioned. To segregate students, giving them a purely aeronautical education, would be a great mistake; the importance of general education could not be over-emphasised. He believed that a general engineering background and a general scientific background were essential to the broad outlook which the aeronautical engineer or scientist must always preserve. Furthermore, purely engineering or purely scientific training was not sufficient; it was necessary also for all the young people who were entering the profession to be trained as far as possible in all the other subjects that mattered, such as history, ethics and economics. Often

had he been impressed in the past by the narrowness of the education of some of those engaged in technical work under his charge. In particular, it had been necessary frequently to teach people the elements of English essay. So that, whatever the system of training decided upon for aeronautical men, it should include, not only skill in the use of the instruments in the cockpit, and the instruments of research such as the wind tunnel, but also skill in the use of that very effective instrument, the English langage.

Another important consideration was that the rewards and opportunities in technical aeronautics, both in the Government service and in industry, must be improved. It would be of little use providing splendid facilities for training in aeronautics—and he was confident that splendid facilities would be provided—if the young men and women whom the profession wished to train, those with brains and initiative, were to decide to become doctors, lawyers, geologists, and so forth because thereby they could achieve a better standard of living than they were likely to achieve in aeronautics. Professionals in aeronautics could claim that their art was not exceeded in quality in any other profession. Therefore, he hoped that the plans for improving the quantity and quality of aeronautical staffs would go hand-in-hand with a recognition of the proper status of the aeronautical expert, with all that such recognition connoted.

The Chairman added that if there were sufficient unanimity of opinion on any points raised in the discussion to warrant the framing of a resolution, he would undertake to convey it to the Council of the Society.

Sir Roy Fedden (*Fellow and Past President*) : He would be as brief as possible, as he knew there were many there to-night who wished to speak and give their views on this most important matter. He felt it was his main duty to say something of what was going on in America in regard to technical training at the present time and to suggest some of the lines upon which the Society ought to take the lead in regard to this whole matter.

Turning first to the question of technical education in America, there is no doubt that that country has made considerable strides in this respect during the last few years and it is reflected in the staffs of the Army and Navy authorities and the industry employed upon all aviation matters, in fact he would go so far as to say that it would not have been possible, no matter what money and effort had been put into the huge aircraft expansion in America to accomplish what has been done in the comparatively short period, had there not been during the period immediately before the war a large step up in technical education in American universities. Generally speaking the mission which he led on behalf of the Ministry of Aircraft Production found that both at Wright Field, the headquarters of the Army Air Force, and the Navy Bureau there was a large number of executive Service personnel who had been in residence for some considerable period and had taken full university engineering courses, many of them post graduate courses in aeronautics at Pasadena and M.I.T. Cambridge, Boston, and that the number of men so equipped was many times greater than exists in the corresponding position in British Services. This applied not only to the junior executives but actually to the most senior men, controlling the design and production sides also.

Turning now to the engineering side of the aircraft industry, the mission found that the design and engineering forces employed at the chief aircraft and engine plants was of the order of five times greater than that which is employed in this country.

Whereas he was not suggesting for a moment that they in this country should aim for the staffs and personnel, either in our Government departments or in the industry, to be on a comparable scale to that which has been set up in America, and in fact he would go so far as to suggest there may be some unnecessary extravagance and duplication with these very large staffs. Nevertheless he was convinced that America had built up an organisation for the design

and development of aircraft and its ancillary equipment which is more highly trained and specialised than over here, and more able to deal with the great developments that they all knew were coming in aviation.

Those who had spent most of their lives on the technical side of aviation and had the utmost belief in its future, know that they had only touched the fringe of what is coming after the war. The present war, it seems to him, must go the same way as regards aviation, as the last war. Then there was a tremendous effort in regard to development, production of quantities of aircraft along conventional lines, but there was no time to think or study for research. When this war is over and there has been an opportunity to recover from the mental strain, they are, he believed, going to see enormous developments in aircraft, and they in this Society had got to make sure that their members and technicians had got the necessary training, background, staff and research equipment to maintain the lead that they had always had in the past.

It is fortunate for this country and the world at large, that there did exist in England somewhere, about 10 years ago, a few enthusiasts with the drive, vision and determination to build up that remarkable series of aircraft which are at the present moment being so excellently handled by the Royal Air Force, and taking such an important part in the war in the air. He believed that no other such team, small though it may have been, had existed in the world.

He suggested that the next family of aircraft which will be produced after the war cannot be evolved in the same way as that of the previous vintage. Aircraft have become so much more complex that they had passed from the state of artistry to applied science. There are so many different groups of engineers wanted that they must increase the engineering forces and organise more on the lines of the American industry, and he seriously considered that this is only possible if they took immediate steps, now, during this present war, to put their house in order in regard to technical education and research equipment.

Broadly speaking, there is no doubt that America has been for some years more alive to the necessity of technical education. In the immediate pre-war years some 14,000 students graduated annually from engineering schools and American universities, of which 10 per cent. specialised on aircraft engineering. In 1942 over 1,400 took aeronautical degrees in U.S.A., whereas there were only 111 in this country, including the Higher National Certificate students. In the latter part of the last century and the early years of this, some fine centres of education were built up in this country to deal with technical matters, but in those days the cost of equipment was minute compared with what is necessary to-day, and they had fallen behind in this respect of recent years.

American is spending about 15 times as much in university education as over here, and in California alone, a State where there is a great deal of aircraft activity, more is spent on university education than in the whole of this country, although the population is only about seven millions. There are about 15 universities that have a sound aviation course, and some six universities in America have excellent post graduate courses in aeronautics. It is because technical education in aeronautics is on this scale in America that the design sides of their industry and their Government departments are able to be staffed with such a large number of technically trained men.

Now because aeronautical engineering and university education in America generally is on the scale that he had described, he did not want them to feel that he was of the opinion that everything is ideal in America in regard to education and that they were all wrong in this country. As is nearly always the case in America, when the need and urge for any new movement is realised there are always many people with money, enthusiasm and drive willing to dash into the breach, and university and technical education is no exception in this respect. Several friends of his in America who have great experience of American technical education were fully alive to the position. There are certain centres of education

which have been set up, in which money has been no object and elaborate buildings and equipment have been installed. Nevertheless there has not been the background and the right type of training, with the consequence that there has been a mass produced pupil in which more attention has been given to the number of attendances than actually to what has been absorbed. However, because these mistakes have been made, they must not pass over or belittle the tremendous work that has been done during the last few years in technical education and especially aeronautical engineering in the universities of America and the work of such men as Dr. Von Karman, Professor Clarke-Milligan, Dr. Hunsaker, Dr. Warner, Dr. Lewis, Dr. Taylor and many others who have been responsible with great determination for planning and vision in regard to the whole question of the training of young Americans in the art of science of aeronautical engineering. These men and their colleagues have been excellently supported by the authorities and have been given money and equipment on a scale that they had never been able to envisage in this country, and the post graduate courses and the syllabus covering a wide variety of subjects are of a very high order and something which they might well study and take advantage of to the full. It will be realised that when the mission returned to England in March of this year fresh from having seen the work that is going on in the different American universities and the training of aeronautical engineers, they were profoundly moved to hear that the small aeronautical post graduate course at the Imperial College of under a dozen students was to be disbanded owing to the demands of the Forces.

While realising the shortage of man power in this country, and how much smaller is the population, nevertheless he submitted that aviation is such a vital matter and is going to play such an important part in peace negotiations and for the post-war years that it is absolutely necessary that they should have a proper nucleus of trained engineers. He considered it is one of the most sacred duties of the oldest Society in aeronautical engineering in the world to do all in their power to see that this matter is put right forthwith.

He would like to consider for a moment what interest had been taken by the Society in aeronautical education in the past. The high standards of the different grades of the Society are known throughout the world, and many members of the Society give a great deal of their time to the examination, selection and grading committee on this important subject. In 1939 a selected number of the Royal Aeronautical Society waited upon the London University Board and asked that a faculty of engineering should be created for aeronautics. This deputation was sympathetically received and it was promised that such a faculty should be set up, and it was hoped the industry would be prepared to absorb about 100 men per year and to pay them a reasonable salary after they have taken their degree, in line with the usual practice in this country with electrical and civil engineers. The Society felt that they had made a move in the right direction, and all preparations were going forward to inaugurate the degree as soon as the war is over.

In 1938 the Council of the Royal Aeronautical Society, with the S.B.A.C., considered the question of aeronautical apprentices and certain of their members having studied what was going on in the Continent, came to the conclusion that the necessity for highly trained and specialised apprentices was so important to the industry, which had just started on its large expansion scheme, that the whole question of the apprenticeship of aircraft mechanics and draughtsmen should receive their serious consideration. A joint committee was set up, which sat for a number of months and a most excellent syllabus was drawn up and a manual was produced by this committee, giving its recommendations in regard to the training of the youth of this country on aeronautical engineering. Unfortunately, the recommendations of this committee were turned down by authorities outside the Society, and what was really a fine move towards increasing the practical skilled potential in the aircraft industry was side-tracked. This does not mean that there are not some excellent engineering apprenticeship schools in the air-

craft industry to-day, but the scale upon which this important question is dealt with is still somewhat limited and requires re-opening on the basis of the report.

Another question which the Council of the Royal Aeronautical Society have given thought to is that of the status and training of the engineers in the Royal Air Force. A deputation of the Council of the Royal Aeronautical Society waited upon the Secretary of State for Air early in 1940 and put before him the proposals of their Society in regard to the upgrading of the engineer officer in the Royal Air Force. Those who have watched the growth of the Royal Air Force over a number of years have felt that the position of the engineer in the R.A.F. is not strong enough, and this was brought home very much indeed during the recent visit to America, where the engineering personnel have considerably more authority and prestige than is the case in the Royal Air Force.

There is no question that the operational officer in the R.A.F. has greater authority than his opposite number on the engineering side. The Society wants to see the position of chief engineer of the Royal Air Force set up, so that this man should hold the rank of not less than Air Chief Marshal and should have a seat on the Air Council and should be able to discuss matters relating to the efficiency of the Air Force and its technical aspects, with the same authority and prestige as his colleagues on the operational side. This is not so at the present time, in fact in some commands there seems to be an inferiority complex in regard to the engineering personnel, although there is no doubt that they have done the most magnificent work under the greatest difficulties.

It is common knowledge amongst the younger fellows of the Royal Air Force that if they specialise in engineering their chances of promotion are not as great as in other branches of the Service, and they are taking a step which may not be popular with their superiors. This is a serious position for this most modern Service in which technical matters are of such vital importance, and he was afraid it was somewhat akin to a trait which went through the whole of both the Service and business side of the country in which the engineer does not receive his full recognition because of the belief that an engineering training does not equip a man suitably to take an executive and administrative ability. This is a state of affairs which is not tolerated either in America or on the Continent.

He considered that it was outside the scope of the Society themselves to attempt to set up educational facilities, but he did hope that it would leave no stone unturned to see that adequate steps were taken in educational and research facilities forthwith, to give the young men who intend to make aviation their profession, the best opportunity to succeed. He suggested that the Society should ventilate and discuss this matter to the full, that they should set up a suitable committee and should produce a report to the suitable authorities of what they feel ought to be done and that they should pursue this matter more energetically in the future and continue to discuss and push this subject with the right authorities until they are convinced that they had obtained what was adequate to meet future needs. He had the utmost faith in the efficiency of the aeronautical engineering fraternity and he believed that if they were given the right opportunity as regards trained staff and research equipment, they could continue to produce the best aircraft in the world.

Professor Sir MELVILL JONES (Chairman of the Aeronautical Research Committee) (*Fellow*) : Naturally all aspects of the subject of education interested him, because in peace-time his profession was the teaching of aeronautics; but the aspect in which he was particularly interested at the moment was the training of students of what might be called post-graduate standard, for the Aeronautical Research Committee had been asked to advise upon it. The problem of training the large numbers of technicians required for the lower posts was equally important; but the Committee was considering training for the higher posts in research and industry and in the Services, though it had not yet drawn up a report. The views he would express would be his own personal views, and must not be

regarded as anticipating or prejudicing the report which the Committee would make.

Assuming, as it must be assumed, that training of the kind in question must be provided in this country in the future on a very much larger scale than in the past, it seemed to him that, broadly speaking, there were two ways of tackling the problem. One was to effect a great expansion of post-graduate teaching in several universities; the other was to create some form of central school, not necessarily to take the place of the teaching in the universities, but to supplement it. Sir Melvill was strongly in favour of the idea of the central school, for he would prefer that the universities should continue the teaching of scientific subjects in their traditional way. So far as he could interpret it, their policy had been always to give the widest possible teaching to the undergraduate on all relevant subjects, but to give post-graduate teaching on a rather narrow line, i.e., to do it through research and on specific researches related to those subjects in which the staff happened to be particularly interested and for which the situation and equipment of the university was suitable. He believed that that was really the way in which a university should work. The alternative of enlarging the staff and the post-graduate work to give a really comprehensive course gave rise to the difficulty—apart from the fact that he did not think it was the right thing to do—that, however few students there were, there would be required quite a number of individual teachers who could deal with a number of different subjects, and very good teachers at that. Again, fairly elaborate apparatus was required for the teaching of aeronautical technique, and he doubted that it was practicable or advisable to try to provide either the necessary numbers of teachers or the apparatus to give comprehensive courses in a great number of universities. He would like to hear comments on his suggestion to establish a central school to supplement the work of the universities.

Enlarging upon the suggestion, Sir Melvill said he would like the school to be situated on an aerodrome, for he considered that all who could learn to fly should be taught to fly; everybody concerned, provided they were not medically unfit, should learn the important technique of making observations in flight, for in future that would become, as indeed it was already, a very important part of technical aeronautics.

Again, he would like to see the school situated near a big research institution, so that there would be excellent facilities for lectures. Some lectures would be given by the staffs of aeronautical firms, and some would be given by men actually engaged in researches connected with the actual subjects on which the students were working. Thus, interest would be very much stimulated. The lectures would perhaps be given around the apparatus concerned, so that students could appreciate the enormous scale of the apparatus required for aeronautical research.

The school should be prepared to accept as students any who could claim the necessary qualifications and preliminary training. But probably a large number would be graduates from the universities and from the Services. Sir Melvill hoped also that, if such a school existed in the country, some of the older men would come back to it from the industry, the Services and the universities for refresher courses. They would bring with them a breath of the outside air and would also give to other students an idea of what life was really like in aeronautics.

Sir Melvill emphasised again that he hoped the establishment of such a school would not be put forward as an excuse for closing down on university post-graduate work. The one central place was necessary to give the comprehensive teaching; but there should also be the specialised research, and teaching through specialised research, in the universities. He would like to see the university post-graduate work continuing roughly on present lines, though enlarged.

He hoped that his frequent references to research would not give rise to the thought that the central school, if established, should be used only or mainly for

training future research workers. Its function would be to raise the standard of technical knowledge, not only in research workers, but in those who would occupy all the higher technical and executive posts in the industry, the Services, and even in the universities. Everything possible should be done to ensure that not only those who occupied the technical posts throughout the country were conversant with technical matters; he would like to see among Ministers (including those who hoped to be Prime Ministers), air marshals, company directors, etc., a good sprinkling of men who had had the advantage of a really fine technical training, for it would be of great value if that condition of affairs could be brought about. It would be a good thing that a certain proportion of the students at the school should be those who would later occupy administrative posts.

Sir FREDERICK HANDLEY PAGE (*Fellow*) (Managing Director, Handley Page, Ltd.): He urged that post-graduate courses should not be concerned only with the training of research workers or the training of graduates through research work; that rather narrowed down their ideas of education to theoretical work not immediately connected with engineering, but connected rather with the technicians' side of the aircraft world.

Two important aspects of aeronautical work to which more attention might well be devoted were engineering production and administration. With regard to production, Sir Frederick pointed out that new methods were being evolved daily, involving new detail processes and the use of new materials. For example, the whole technique of pressing out materials to form cowlings and similar pieces in the make-up of an aeroplane, involving pressing, stamping, stretching, stressing, and so forth, had behind it a really scientific basis to which more research should be devoted. On the production side of aircraft they should encourage those who were engineers rather than technicians and who desired to go more deeply into the methods by which articles were made, and should give them greater opportunity to take a post-graduate course. The widening of educational facilities in that way would involve a good deal more expense and equipment than the training of technicians only. A technician was perhaps a person who, by his brain alone, without the aid of equipment, could evolve great ideas, express them on paper and make great inventions. From the point of view of the individual, that was the best thing to do, for it did not cost very much and the reward was open to be out of all proportion to the initial outlay. But for the study of engineering production methods, very heavy and expensive equipment was needed. Nevertheless, that aspect must be given due consideration when reviewing facilities for post-graduate courses.

With regard to the administrative side of engineering, any long programme needed planning, and the planning needed progressing; the whole thing must go forward in an orderly and well-balanced sequence. Technicians very often looked down on such matters, which were commercial, and therefore were regarded as being on rather a lower scale. The people engaged on that kind of administrative work very often came into the industry by the "tradesmen's entrance." If we were really going to do their work properly in this country, more attention must be given to that aspect of engineering. A matter which had impressed him in connection with American research was the administrative ability that was available and which governed the general outlook of research organisations; and they needed more of it here. Therefore, they should encourage proper training.

As an example of the importance of proper administration in connection with aviation development, Sir Frederick mentioned the organisation of test flying, a very expensive matter. Provided it was paid for by a Government, either as part of the contract or as an all-too-little "extra" to the contract, well and good! But when it came to making aircraft for commercial purposes, where ultimately a passenger would pay a fare no higher than a first-class liner fare, costs were very important. The initial development charges might include the cost of a very

expensive series of tests; the proper administration of that work, with a view to carrying out a great deal of testing in the course of a small number of flights, was obviously essential.

Again, in connection with the actual production of the aircraft, the whole series of manufacturing operations had to be planned, and everything possible must be done to cut out heavy drawing office charges. In connection with such matters a good deal more thought might be given to the basic system under which they operated, and they must give attention to research in production methods and administration.

There were two different kinds of people in this country who needed education for industry. First, there was the kind of person who, by reason of his circumstances, could not continue his ordinary school education up to the stage at which it was usual to enter a university; at an early age he would enter the hard school of life in the works, where he would learn engineering, for he knew that either he must learn or he would sink. That was really the best way in which to learn all the details. The second kind of individual, more fortunate, remained at school until he entered a university; he received a really good education from the point of view of book learning, with perhaps a minimum of practical work. Probably he knew that he had a good job awaiting him, whether he worked or not, and he did not become educated in the same way as the person who had to earn his living. It was most difficult to ensure that a person who had been educated at an engineering college or a university would follow that up by a really good education in the works; and the more money he had, the more difficult it was to educate him. That was one of the chief problems to be solved; presumably it would be studied when they had established the research organisation and central college of which Sir Melvill Jones had spoken, and at which they could teach students everything they ought to learn. Then they could hope to give technical training to potential Prime Ministers, air marshals or even company directors!

Sir Roy Fedden: Sir Frederick would be interested in the M.I.T. Bulletin, which referred to several courses such as he had outlined.

Professor W. J. Duncan (*Fellow*) (Wakefield Professor of Aeronautics, University College, Hull): He expressed his whole-hearted agreement with Sir Melvill Jones in regard to the establishment of a central post-graduate school. Discussing the more ordinary university course for aeronautical engineers and the references made to the avoidance of undue specialisation, he said the idea that specialisation must be avoided in aeronautical engineering education, and in engineering education generally, was liable to be carried rather too far. His view was that there must be a certain element of specialisation in all engineering education; otherwise it became merely training "in a vacuum." His ideal for the educating of the ordinary aeronautical engineer was to provide first a good basic training in all the subjects normally included in the ordinary liberal education, and then a training in general science and mathematics and, more especially, in mechanics. But the whole professional education should have a definite bias towards the student's life work; and that did not necessarily imply undue specialisation or narrowness. Indeed, if a man were well trained in aeronautical engineering he should be very capable in almost any branch of engineering, except perhaps in the very highly specialised branches, such as electrical engineering.

Supporting the Chairman's reference to the need for the study of English, and especially the writing of English, Professor Duncan said that one of the most outstanding defects in the young men from the schools and universities was that they were very poor writers of reports, taking them by and large. In research institutions and the like they acquired in the course of time a certain amount of ability and facility in that direction; but when they first joined those institutions they were, on the average, deplorably bad.

Outlining briefly a scheme of education for aeronautical engineers which had been operating at University College, Hull, for the past nine years, Professor

Duncan said that in many respects it fitted in with modern ideas. Under that scheme, young men left school at about the age of 17 years and entered the aeronautical industry as apprentices. They spent two years in the works; and, of course, in a good firm they would gain experience in a number of departments and would learn many things. During that period of shop training they had to attend evening classes at a technical college; and at the end of it they were expected to pass the National Certificate examination in mechanical engineering. (Incidentally, Professor Duncan expressed the hope that after the war the class work associated with the works training would not have to be done in the evenings, for he considered that to be a vicious system.) Assuming a student had passed the necessary entrance examination, he would spend the next two years at college on an academic course which carried him forward through the usual engineering subjects and a certain number of specialised aeronautical subjects. At the end of that period of two years he would sit for an examination; if he were successful in that examination he was entitled to receive the diploma of the college, provided that he completed satisfactorily another nine months of practical work. That final period of nine months was spent normally in the drawing office, stress office or the wind tunnel or aerodynamics department of the firm concerned.

Without wishing to boost his own wares, Professor Duncan commended that type of training as being sound and not unduly specialised for the average engineer and technician who proposed to enter the aeronautical industry.

Mr. C. C. Ferguson (Fairey Aviation Company, Ltd.): He emphasised the importance of proper training for those who were to carry out the manufacturing processes, and said that if the industry were to hold its proper place after the war it must not only attract the people who were to occupy the highest positions, but also a large number of boys who were leaving school and who would ultimately lead the rank and file in the workshops. Therefore, whatever educational scheme was evolved, it must definitely cater for all classes of workers. Looking at the matter from that point of view, he felt that the Society, in conjunction with the industry, must take a greater interest, not only in boys of school-leaving age, but also in the younger boys who were still at school. In London there were the primary schools, the central schools, the technical schools and the secondary schools; owing to three "creamings" for the three previous schools having occurred the primary schools were regarded as providing a low grade of labour. Nevertheless, industry must employ such labour, for many minor processes and routine operations. In the air craft and general engineering industries there were varied tasks which demanded the employment of all type of workers, from the products of the primary schools to those of the universities. Throughout many years education schemes had been established by the City and Guilds of London Institutes, the university authorities, and so on, in the majority of cases with the guidance of committees whose members represented employers and professional institutions. Was it not possible to build up, from a study of a large number of such schemes, a scheme which would meet the requirements of the aircraft industry? Having been connected with the aircraft industry and with other branches of engineering for more than 20 years, he felt that it was impossible for the aircraft industry to be divorced from general engineering; the elementary training must be practically the same, the machine tools used were almost identical, the bench operations and the control of labour were almost identical in any branch of engineering industry. If the aircraft industry were to attempt to divorce itself from general engineering it would invite serious adverse criticism, and it would possibly lose a large number of its potential craftsmen and technicians, who would wish to be trained for a wide field rather than a narrow one. Such aspects of the problem should be taken into consideration.

Emphasising that it was absolutely essential that those engaged on production engineering in the industry must be trained along scientific lines, Mr. Ferguson said that they must be capable of putting into rapid operation the modifications

that had to be made from time to time. The men who must take charge of the workshops must also know how to handle the workpeople; they must be trained on managerial lines.

Mr. W. E. W. PETTER (*Associate Fellow*) (Westland Aircraft Co.): In discussing the demand for and the supply of engineers and technicians in the industry, he divided them into three groups. The first group comprised the skilled mechanics, and they constituted the greatest number. The second group comprised the assistant designers, the section-leader type of engineer and his opposite number in the factory, the planning engineer, the progress engineers and those capable of dealing with workpeople on the administrative level. The third group was quite a small one, comprising the leaders in the technical and manufacturing departments, who might be recruited directly from the universities or might rise from the ranks of the first and second groups. The arrangements existing before the war, in the capable hands of such men as Professor Sir Melvill Jones and Professor Duncan (if those arrangements were adequately expanded) would meet the needs of the third group, bearing in mind also that there should be opportunities for promotion from the other groups.

Expressing particular concern with regard to the second group (the assistant designers, planning engineers, etc.), Mr. Petter said that the industry's efforts were being held back by the desperate shortage of such men. That state of affairs had arisen from the method of training adopted in the past, and from a lack of recognition of the immensely important work which people on that level were doing.

The Westland Company, he continued, had instituted in 1936, when it had become financially possible, a three-grade apprentice scheme. For the apprentice section which especially envisaged training for duties coming within the second of the above groups the Company insisted on the qualification of matriculation or school certificate standard. He was quite sure that the minimum general education standard was necessary for those who were to be trained specifically for duties corresponding to the second group, or higher. The recruitment of 300 such people per annum would call for a vastly expanded intake into the industry. However, the system used at Westlands had been found to work, so far as it went. Boys who entered at 18 years of age, with matriculation or school certificate standard, were given a three-years' course in the shops, and also attended evening classes. He felt that after the war there should be part-time day training classes.

Group-Captain G. W. WILLIAMSON (*Fellow*): In considering the apprenticeship problem in relation to the aircraft industry it was necessary to bear in mind the serious situation which had arisen in industry generally at the close of the last war. Engineering concerns of all types were unaware of the kind of work which would fall to them at the end of the war, the contracts they would obtain and the numbers of men available; most of the great firms had declined to take apprentices merely because they had no idea what their future would be. That sort of condition would arise again, particularly in the aircraft industry. It would be necessary to obtain guidance also as to the kinds of orders which would be placed, not only through the Air Ministry and M.A.P., but from other sources; and whether those orders would constitute a sufficient guarantee of security of tenure for any young man who elected to take up an apprenticeship with some great firm, or a guarantee that a firm could take apprentices up to a certain number with a reasonable likelihood of being able to employ them regularly and at reasonable salaries. In his view it was for the Government to make investigations with regard to the numbers of apprentices that could be taken on by the industry and their distribution amongst the factories.

Whether one considered training for research or design or the training of the rank and file, some method of selection was necessary. The National Institute of Industrial Psychology had had long experience of the selection of personnel for industries, though it was perhaps unfortunate that efforts had been applied mostly

to the determination of the standard of intelligence of the persons concerned, instead of proving whether or not they possessed reasonable facility of application. However, if a person had intelligence without application his enthusiasm might wane if the path proved long and difficult. It was really necessary to develop a method of selection which would show whether or not the individual youngsters were likely to prove worthy of training for managerial positions, production staff, or other spheres. There were already in being in this country one or two systems of selecting and training apprentices, such as those applied by Imperial Chemical Industries, Ltd., and the Metropolitan-Vickers organisation. He had been told that the practice of I.C.I. before the war was to select possible future employees during the second year of their training at a college, and thereafter to maintain a close liaison with the selected youngsters. At the end of their third year, if no post-graduate work were intended, I.C.I. would, at its own expense, send the selected youngsters to work for some other firm for two years, and at the end of that period it would give them the choice of staying where they were or of joining the I.C.I. organisation. That was a gesture which indicated the broad-mindedness of that great firm.

Discussing the training of engineer officers in the Services, Group-Captain Williamson recalled that, 16 or 17 years ago, it was his task, in conjunction with others, to build up an R.A.F. school for engineer officers. They had taken advice from the United States, for at White Field there was a comparable administration in full working order, producing engineers of very high quality, capable of research and development. That organisation had received only 12 engineer officers per annum, and for their training there were 64 instructors, whereas in the engineering school established in this country there were 60 officers and 10 instructors, most of the latter being very poorly paid. At about that time the Air Ministry had issued an Order guaranteeing the position of the officers selected for engineering and development work; it had made certain promises in regard to accelerated promotion, not all of which were kept. Indeed, it was a common belief amongst young would-be engineer officers that it was detrimental to their careers to transfer to an engineering branch of the Service. Some years ago the Institution of Mechanical Engineers, the Royal Aeronautical Society and another body had approached the Admiralty to secure for engineer officers in the Navy and R.A.F. an improvement of status and a reasonable rate of promotion, akin to that of their more fortunate colleagues on the deck and in the administrative and operational spheres of the R.A.F. But it was doubtful whether the great Institutions could offer advice to a fighting Service in time of war. It was strange that automatically, when a man had trained as an engineer, he was regarded as being incapable of administration or command.

Finally, Group-Captain Williamson said he had been fortunate in having served under Sir Hugh Dowding, perhaps the greatest Air Member for Supply and Research, and the only one who had seen all his dreams come true; Sir Hugh had given him a testimonial to the effect that: "This officer is a highly qualified engineer, a fact which has been a hindrance rather than a help to him throughout the whole of his service."

Mr. R. HADEKEL (*Associate Fellow*): He suggested that to try to evolve a scheme of training, the object of which was to produce a good engineer, was to over-rate altogether the possibilities of training. In his view, only experience could make a good engineer; therefore, the object of training should be to produce the graduate who would become, with good experience, as good an engineer as possible as quickly as possible. The way in which to achieve that object was to enable the student to learn at a university, or at whatever form of institution was selected, those things which it was most difficult for him to learn later when actually engaged at his job; and which it was difficult to learn from a text book.

Hence, it seemed to him that the present technique of the universities was fundamentally right and should be encouraged and continued; it was also right that the

regular staffs of the universities should consist of eminent authorities with often a more scientific than engineering bent. But if the present system of teaching at the universities continued, it could be supplemented very usefully by calling upon industry and the Government Departments to provide men to give lectures in addition to the lectures given by the university staffs. They would be men who had played their part in the engineering profession, and they would give the student another kind of teaching which would make him feel, when he came up, that he was not looked down upon as merely a young scientist, but that he was really in the swim and was directly in touch with the latest developments—and developments were rapid in aeronautics.

On the question of status, he said that whereas on the Continent the title " engineer " implied a status similar to that of the doctor or the lawyer, in this country one could not help feeling that it was still " not quite the thing " to be an engineer. A fundamental difficulty, which one would like to see eradicated, was the definition of the word " engineer " in the English language; it meant anything from a mechanic to a Director of Research. The problem should not be tackled piecemeal; probably it could best be tackled by the creation of a Council of Engineering Institutions, working in some respects on lines parallel with those of the General Medical Council.

Mr. A. E. PARNACOTT: He urged that education should not be based on current practice. It should always be conducted with a view to future developments, and the students should have a full appreciation of the engineering problems awaiting solution, for it was only by the evolution of new designs, which could be dealt with on mass production lines, that this country had any chance of meeting competition from overseas. After alleging that progressive people in the Air Ministry had been discouraged, he said that many opportunities had been lost by engineers, and urged that, to enable this country to hold its own, it was essential to encourage and foster the leaders of development.

Mr. T. R. THOMAS (Secretary, Air Registration Board) (*Associate Fellow*): He urged that the Society, in considering training proposals, should give thought to the possible general position of the aeronautical industry after the war. He could not conceive that it would be able to support then anything like the number of technicians, of the grades under discussion, that it employed in war-time; therefore, although the schemes suggested seemed perfectly sound, they must be necessarily on a very small scale. Advanced post graduate training, referred to by Sir Roy Fedden, would also necessarily be on a small scale. It was not suggested, of course, that technical education in fairly large measure was not desirable. But he had always felt that the great weakness of the universities was that the people they turned out with degrees had the idea fixed in their heads that they did not belong to practical engineering, but must earn their living in the drawing office or in the stress office. That idea was entirely wrong. He would like to see every man of the type called for by Sir Frederick Handley Page, such as the production engineers, the men who would occupy administrative posts in the works, and so on, holding a degree, for if a man were to carry out his duties efficiently in any of those capacities he must have a very good general knowledge of aeronautical engineering such as could be obtained only at a university.

Mr. Thomas's excuse for taking part in the discussion was his interest in the education of a very large body of engineers, i.e., the men responsible for the maintenance of the airworthiness of civil aircraft. During the past 20 years, he said, at least 5,000 of those men had been licensed by the Air Ministry. Those licences had been issued during the past five years on the recommendation of the Air Registration Board, and he was glad to say that the Board was doing its best to raise the standard of those men. Those men fulfilled a very important function in ensuring the successful operation of the aircraft which were designed by members of the Royal Aeronautical Society, and they deserved a little more

recognition perhaps from the education point of view than they had enjoyed so far. At the some time, gratitude was due to schools of the type of the De Havilland Aircraft School, which had been responsible for the training, not only of those men, but also of the type of men of whom Sir Frederick Handley Page had spoken. It was important that any scheme or proposed scheme for the education of aircraft engineers should embrace the education of the lower grades.

THE CHAIRMAN: He would like to recall that in his opening remarks he had made the point which Mr. Thomas had made. In defence of the Council of the Society it was right to say that it had taken a great interest in the ground engineers, and was satisfied that the standard of certification of those men was in very good hands.

Sir LINDSAY EVERARD (*Companion*) : In commenting on a remark that had been made to the effect that aeronautics was regarded as the Cinderella of industry, he said it was necessary to eradicate that sort of idea. He favoured making a clean sweep after the war and setting up an aeronautical university, with the help of those who had assisted so much in the existing universities. He held a Cambridge University Degree; but if he tried to get a job in the engineering industry, or as a pilot, it would not help him very much—or it would not help his employers very much if they appointed him! If, however, he took a degree at an aeronautical college, his employers would know that he was qualified in at least one of the sciences of aeronautics. The attitude of the public towards aeronautical science would change if there were established a large university for the training of scientists and engineers who were to work on the ground as well as in the air, and the training of pilots up to a certain stage; there should be also a large national laboratory for research, so that the whole organisation would be concentrated in one centre. It might be called, for example, " The Air Training Centre of Great Britain." Everybody who had studied there would be recognised as an expert in one or other aspect of the science of aeronautics, and the public would have the confidence it ought to have in the industry as civil aviation progressed in the way it should do.

In supporting that proposition Sir Lindsay was emboldened by the success of the well-known engineering college at Loughborough, which was set up at the end of the last war. It was an extremly good engineering college, attended by students from all over the British Empire, and there was no other in England that was conducted in the same way. If that college could have been established after the last war, surely there must be many places which would be suitable for the establishment of an aeronautical university after this war, bearing in mind the enormous numbers of buildings of various kinds which had been erected by the Ministries.

Wing-Commander T. R. CAVE-BROWNE-CAVE (*Fellow*) (Professor of Engineering, University College, Southampton) : It was probably agreed that for the higher stages there must be specialisation. Also, for the National Certificate stage, where training was to be taken by men who could devote only a comparatively small proportion of their time to them, even up to 50 per cent., there must be specialisation, for they were trying to learn as much of certain very difficult technical processes as they could in a limited time. But for the university graduate he hoped that specialisation would be deferred as long as possible. A man should take a general degree course in engineering, at any rate up to the pass degree stage. If he were going to specialise in aeronautical or civil or electrical engineering he should do so after that stage. The general trend of opinion seemed to be in that direction almost universally.

It would be interesting to know what the industry and the profession as a whole thought of that. If a man had devoted, say, three years to a university education, would he be of greatest value if he had a good deal of detailed knowledge of aeronautical subjects, or if he had a good knowledge of the fundamental principles of engineering, as distinct from current practice in aeronautics? Wing-

Commander Cave felt that a wide knowledge of general principles was by far the more valuable attainment. Industry as a whole, and aeronautics in particular, were advancing so rapidly in so many unexpected directions that the only way in which to make a man capable of dealing with those developments was to give him some knowledge of the fundamental principles of quite a wide range of engineering subjects.

The importance of teaching people to express themselves concisely and clearly was by no means adequately realised. The inability of many people so to express themselves was reflected in reports, and certainly in the Press; it was most important that people should be able to express clearly, both verbally and in writing, their thoughts on any subject. Certainly it had been his experience, and probably it was the experience of many others, that it was far more difficult to persuade one's seniors that what one wanted to do was right than to find out what was the right thing to do. To a certain extent it might be the fault of the seniors; but to a very large extent it was due to the fact that the people best qualified to determine the right thing to do had habitually neglected to develop the ability to express it clearly.

(*Contributed.*)—In addition to the observations which he made at the meeting on 25th June, 1943, he would like to submit:—

That the three general grades provided by

1. Apprenticeship with Higher National Certificates and extensions.
2. Degree or Associate Fellowship with less practical experience.
3. Post Graduate work with experience of scientific testing and research,

should not be looked upon as having different fundamental merit or status, provided each is developed to the full with continued study over equal periods. They call for differing qualities, but all are important. The pay which they will command will ultimately depend on their value and the supply. It is important that the Society and the Industry should take equal care of the practical and the theoretical part of each of the three groups of qualifications.

The degree or other intermediate standards of technical education should not be made primarily suitable as a means of sorting out and preparing those who are going on to higher degrees. Each stage should be primarily suitable for those, the great majority, who will finish at that stage. The brilliant few who are going on need much less consideration than do the many who are finishing at that stage.

The mathematics introduced at each stage should be no more difficult than is absolutely necessary for that stage. It is mathematics which frightens and then stops many students who could learn and use somewhat higher work if it were not made so dependent upon mathematics. The mathematics taught should be limited to those processes which the student will later be able to remember and use with real confidence. In most real problems the assumptions and the interpretation of the result are more vital than the intervening mathematics which can be more easily done or checked by someone with less real engineering knowledge and judgment.

The degree should be as wide and unspecialised as possible. It should cover the fundamental principles, as distinct from the current practice, of many subjects, so that the graduate can later use them with confidence in other applications.

Aeronautics advances so rapidly in such unexpected directions that an organism which necessarily moves with the majestic deliberation of a degree syllabus cannot hope to do more than cover basic principles. But if the degree is confined to a simple treatment of really essential basic principles it can cover a very wide range of the subjects which may be involved in later developments.

The transcending object of engineering education must be to make the engineer able and lastingly keen to go on educating himself without the coercion and artificial assistance he has had in gradually decreasing measure "when he was very young." And this should apply to the practical man and the executive

as much as to the designer or research worker. It is in stimulating and helping this later education that the Society and its branches does (in peace time at any rate) do such a valuable job.

Squadron-Leader D. HILTON GRUNDY (*Associate Fellow*): Speaking as an Engineer Officer, he said he had spent three years at Halton, and considered that without wartime restrictions the aeronautical training provided there was as good as could be obtained at any other establishment covering the same syllabus. When he left Halton, however, his hopes of developing the knowledge already gained were dashed to the ground because of the attitude prevailing at that time; that attitude, however, which favoured the manual rather than the theoretical, was dying out with the age of bracing wires and struts. He would like to see Halton considered to be a primary technical training establishmnt in the Royal Air Force, with the addition of a post-graduate course in aeronautical engineering.

In peace-time a certain number of apprentices on leaving Halton were selected for commissions in the G.D. branch on the merits of their technical knowledge and training. On this basis, therefore, this qualification should be sufficient to merit the award of a number of technical cadetships, so that these cadets could continue their studies at an aeronautical engineering university, becoming really useful Engineer Officers at a stage in their lives early enough to give them adequate opportunity for advancement. In short, a career would be open to them at the beginning of their Service life instead of in the closing stages, which is the present position for any ex-apprentice who is commissioned when he has gained senior N.C.O. or warrant rank.

Some Engineer Officers who entered the Royal Air Force since the outbreak of war may have felt that they could have done better, for although their engineering knowledge was extensive they had to concentrate their efforts on routine maintenance and inspection and other elementary work. Recent developments, however, indicate that there will be greater scope for the application of their ability in organisation and planning and of their knowledge of theory.

Finally, he agreed that all Engineer Officers should be able to fly. All who entered the Royal Air Force during peace-time conditions were submitted to a fairly rigorous medical examination, which should be sufficient at least to enable them to take elementary flying training, which would be a great asset to any engineer.

Mr. F. G. MILES (*Fellow*): In emphasising the needs of the country and of the aeronautical industry for technicians, he said that the industry was comparatively new, it was free-minded and was ready to try experiments, and it should take a lead in formulating proper schemes of education. People with creative minds were needed; they must be given a really wide background of knowledge in order to be able to develop their creative abilities and to be able to appreciate fully the purpose of any task on which they were engaged. Welcoming and supporting the proposal to establish an aeronautical university, he urged that it should be called a "university," for that title would indicate that it was not intended to provide a narrow specialised training, but a broad training forming a real basis for future activities in any branches of the industry. The maintenance of close contact between learning and research was also most important, for people learned best when in action, when they were able to see ideas brought to fruition under their own eyes and hands.

THE CHAIRMAN: It would be of great advantage to resume the discussion at a later date; in the meantime the proposals and remarks which had been made could be studied, so that still more constructive ideas could be put forward. When the discussion was resumed there should be a very definite attempt to rationalise ideas and to put forward further definite suggestions likely to be useful to those whose business it would be to prepare schemes for the consideration, he hoped, of His Majesty's Government.

Squadron-Leader J. H. HADDON (*Fellow*) (Education Officer) (*contributed*): It seems to me necessary that students should be trained by men with practical experience in aeronautics and not, as is so often now the case, by lecturers who have only read up the subjects, have no background and do not know what will be required of their students in industry.

One sees advertisements for lecturers in aeronautics offering a salary up to £480 for graduates with over 15 years' teaching and industrial experience. Except in times of slump no suitable man can be obtained for so meagre a salary. Unless educational authorities are prepared to offer much more than the Burnham scale, aeronautical students will be trained by inexperienced teachers, or by those who are failures in industry. The lectures of such instructors are uninspired and often full of errors, but they are allowed to work havoc undisturbed because the principals, under whom they work, are even more ignorant of aeronautics.

T. G. JOHN, Managing Director, Alvis, Ltd. (*Fellow*) (*contributed*): In many ways these problems of education and training and the results derived therefrom are common to all branches of modern engineering, but as aeronautical engineering is perhaps the most modern industry of all, their importance is relatively greater therein.

He thought many people similarly placed to himself will agree that such engineering education up to now leaves a lot to be desired. After all is said and done, the object of this education is to produce results in having available for use men who will have the necessary mathematical, scientific, mechanical, and practical knowledge at their disposal, but more important still, have the individual personality, the initiative and courage to make them self-reliant, progressive leaders of men, and in time, after gaining adequate experience, to make them pillars of future British aeronautical engineering industry.

Why is it that, although there are notable exceptions, yet in so many cases to-day these qualities are so lamentably absent? He thought the trouble could be placed under three headings:—

(*a*) Insufficient attention is given to selecting the right people to be educated or trained.

(*b*) Insufficient care is taken in selecting the people who do the teaching and training.

(*c*) Managements are often badly organised for bringing the best out of the people they receive from the teaching and training centres.

In regard to (*a*) it must be remembered that the paths of education have been made vastly easier when compared with those pertaining until quite recently. Many of the great names in modern engineering industry had very poor facilities for learning; scholarships were rare, and the training frequently consisted mostly of "cramming" for the purpose of passing stereotyped examinations laid down by the Board of Education or similar bodies, who knew little of the practical needs of industry. For instance, when he at one time sat for a Whitworth Engineering Scholarship (of which only four were awarded each year), the award was made on the aggregate number of marks gained from taking an almost unlimited number of examinations on papers set by the Board of Education on all sorts of subjects, such as pure and applied mathematics, geometry theoretical and applied, chemistry (organic, inorganic, and practical), physics, even including free-hand drawing, and so on, the choice and number of subjects being left to the candidate. Subsequent training was continued on more or less the same lines, and eventually when the pupil emerged he had about twice as much knowledge of many subjects as what he really needed in after-life, and not nearly enough of things that really mattered. He often could do much calculus, and yet be shaky on first principles of calculations.

Developments of character, initiative, and of all the other most desirable attributes were ignored entirely. It is no wonder that there were so many failures in after-life of people so ill-trained, and it is a fact that many of the

people who succeeded in the engineering professions were largely self-educated and self-trained. Such men might not, of course, succeed in the era in which they now live and in the conditions which are likely to face them in the future. Anyhow, such handicaps did tend to give the young engineer of those days some considerable degree of self-reliance, which did so much to make him successful.

The selection of the people entrusted to teach engineering subjects is of very great importance. In the days of which he spoke anybody could decide that he would become a teacher of engineering subjects, and if he passed the necessary examinations there was not much to prevent him obtaining his desire, but he was sure that not more than a third of these people should ever have been allowed to take up such a responsible task. Many so-called teachers, well decorated with scholastic degrees, simply cannot teach at all—their personalities are all wrong. Comparatively few are endowed with the genius to imbue an engineering pupil with the necessary interest in a subject, and with the longing to become a brilliant success in his future vocation, and he thought the position was not very different to-day. In other words, selection of the right sort of teacher is of paramount importance to achieve the desired result.

As regards the faults of managements in not making the best use of the human material sent them from the universities, colleges, and technical schools, it so often happens that the heads of departments are themselves too busy and engrossed in their work to give proper attention to it, particularly in times like the present, and too often those to whom they depute this responsible task are themselves of the wrong temperament or have the wrong training to make them fully suitable for doing this.

He had thought over and over again when interviewing ambitious pupils or young engineers—sometimes very hard working—sometimes full of ambition—what a tragedy it was that a little advice given in the right way, at the right time, and by the right person, would have made such a vast difference to their future careers, and yet they did not receive it. It would have been beneficial both from the point of view of their own interests and of the industry.

Apart from all the foregoing is the need of broadening the education and training of the young aeronautical pupil or engineer. Too often one finds that, say a draughtsman or a designer, knows so little about the other parts of a modern engineering organisation such as those relating to the practical operations or matters of costing and so on, and worse still, has no desire to learn anything about it all.

Whether such deficiency of education can be made good at the teaching centre he did not know—probably it should be a joint responsibility of both the teaching centres and of the works.

In conclusion he would like to emphasise that too often people talked from the quantitative rather than from the qualitative aspects of this problem of education, and by largely increasing educational facilities alone they could not be sure of getting what the aeronautical industry needs. A well-trained man is often worth half a dozen badly trained ones.

C. H. Roberts (Principal, Chelsea College of Aeronautical Engineers) (*contributed*): The problem of training the personnel for post-war commercial aviation is obviously a complex and difficult one but it is the first, and one of the most important, steps to be taken if the British Empire is to hold its own in aircraft and engine manufacturing and air transportation.

The subject goes much further than supplying the aircraft industry with a greater number of research and design technicians. Surely the object should be:

(*a*) To attract the best type of men for ALL branches of the industry and
(*b*) To train them to the highest standard possible for the work for which they are most suitable, whether it be technical, practical, administrative, etc.

It is so obviously of the utmost importance that Britain should hold her own in air transport and with British-built machines, that it should have the pick of the engineering brains of the country to carry it out.

During the last twelve years he had had considerable experience in the training or aeronautical engineers and, in his opinion, the following fundamental principles should be adopted in any training scheme if it is to provide the material which the industry needs.

Every applicant for entry to aviation, selected for his educational standards or on his headmaster's reports, should be required to undergo a probationary period of training under a curriculum designed to test his suitability for that branch of aeronautical work for which he shows a preference.

This probationary period would include both practical work and theoretical studies and only those who show proof of ability and suitability for the industry would be accepted for further training.

Records would be kept of character, mechanical aptitude and practical ability and they would form the nucleus of the trainee's record through the whole of his early career and would enable the industry to guide him into the most suitable branch.

The training which would follow the probationary period—whether it be by means of progress through a manufacturing works, by technical school education or university—should follow a curriculum which is approved by the industry and, at some suitable time in the training period, include an opportunity of gaining a comprehensive experience of various types of engine and aircraft, a knowledge of all branches of aeronautics, together with a grounding in commercial and other subjects, including English and a foreign language, which would be of specific value to all who are likely to rise to executive or administrative positions.

This specialised training would be of an essentially practical nature, combined with the complementary theoretical instruction and would cover a wide variety of work on different types of engines, aircraft and instruments—both British and foreign—and in other general workshops to enable the student to acquire a breadth of practical experience apart from the individual productions of the works or operating company with whom he is training.

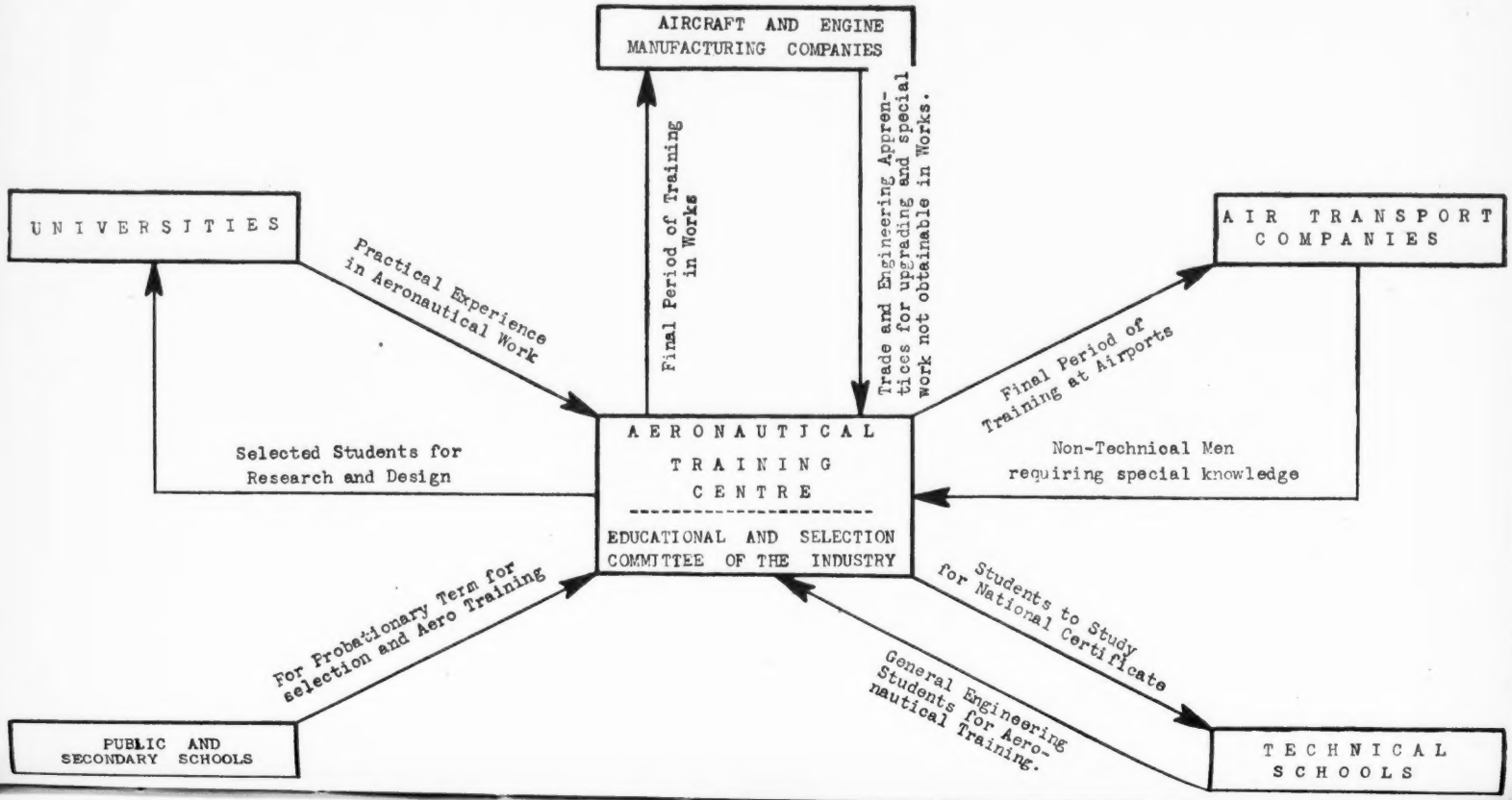
The period set for this section of the students' education should be of varying length according to the branch of the industry he is entering and the extent of the educational facilities available to him there.

It thus provides a corollary of practical experience for the university graduate, enables the advanced engineering student from the technical school to gain a specific aeronautical training in addition to his general engineering curriculum and offers the trade apprentice an opportunity of upgrading. It also provides a specific training for the specialised work of the air transport companies and a broad technical knowledge of his work for the future executive or administrative man.

This training should be available to the industry in one or more convenient centres and an Education Committee, representative of the industry, should be formed to lay down the requirements and syllabus of training and to follow the students' progress. Existing schools of practical aeronautical engineering, Loughborough College, the College of Aeronautical Engineering at Chelsea, the De Havilland Technical School, etc., could undertake the work of the training centres.

The value to the industry of these practical training centres can be tabulated, roughly in the following, and by means of the attached chart:—

1. It enables all aspirants to the industry to pass through a selective course of practical and theoretical work and be accepted or rejected on its results.


AIRCRAFT AND ENGINE MANUFACTURING COMPANIES
UNIVERSITIES
AIR TRANSPORT COMPANIES
Practical Experience in Aeronautical Work
Final Period of Training in Works
Trade and Engineering Apprentices for upgrading and special work not obtainable in Works.
Final Period of Training at Airports
Selected Students for Research and Design
AERONAUTICAL TRAINING CENTRE
EDUCATIONAL AND SELECTION COMMITTEE OF THE INDUSTRY
Non-Technical Men requiring special knowledge
For Probationary Term for selection and Aero Training
Students to Study for National Certificate
General Engineering Students for Aeronautical Training.
PUBLIC AND SECONDARY SCHOOLS
TECHNICAL SCHOOLS

2. It provides a thorough practical training in ALL the essentials necessary together with a fundimental theoretical training.
3. The Education Committee can gain a first-hand knowledge of each student and advise him as to his suitability for any particular branch.
4. It provides training in those subjects which may not be usually available in manufacturing firms.
5. It provides training in specialised aeronautical subjects to the boy from the technical school.
6. It offers the university graduate the opportunity to gain practical aeronautical engineering experience.
7. It includes training in administration for air transportation.
8. It provides a suitable up-grading training for trade apprentices.
9. It can select and coach suitable students for entrance to the universities for advanced studies in aeronautics and coaching for the R.Ae.S. Fellowship examinations.
10. It enables manufacturers and air transport companies to select suitable students for final training with them.
11. It provides a pool of trained men from which the Industry can draw according to its requirements and acts as a clearing house for personnel.
12. It enables entrance to the industry to be controlled according to the demand.

For this system to be a success it would need the co-operation of the Government, the manufacturers, air transport, universities, technical and other training colleges, secondary and public schools and, for those who cannot afford training fees, entrance should be available by means of scholarships, training grants, and reduced training fees.

He had only touched on the problem very briefly but the system had been followed by the College of Aeronautical Engineering since its inception and a similar system, adapted to an extent compatable with the requirements of the industry of the future, should show similarly good results. As examples, the system he had advocated and put into operation had filled such widely different posts as works manager to one of the largest air line companies, assistant chief designer, chief planning engineer, Senior Technical Officer, M.A.P., Chief Inspector, A.I.D., transatlantic pilot, technical officers in R.A.F. and F.A.A., and draughtsmen.

O. S. Sinnatt (late Professor of Aeronautical Science, R.A.F. College, Cranwell, *Associate Fellow*) (*contributed*): The accompanying diagram gives the outline of a scheme for the education and training of aeronautical engineers built round a central College of Aeronautical Science under the direct control of the Lord Privy Seal aided by a committee of representatives of the Royal Air Force, Admiralty, Board of Education, Civil Air Transport, R.A.E., N.P.L., Airframe and Engine Manufacturers and the R.Ae. Society.

It will be staffed by the most eminent professors of science, engineering and mathematics who are devoting their whole attention to the science of aeronautics and its applications.

The college must be the focus of all the latest aeronautical knowledge and the centre of ultimate appeal for information on all matters pertaining to the science of flying in all its branches.

The college will receive much of its information by maintaining a close touch with the R.A.E., N.P.L., Airframe and Engine Builders, and lectures by members of the staffs of these institutions will be an integral part of the curriculum.

The usual channels of admittance to the college will be through the universities, R.A.F. Engineering School, technical colleges, etc., and the standard of knowledge

SCHOOLS
Public, Secondary, Technical
R.A.F. COLLEGE
Correspondence
Squadrons Civil
R.A.F. and Civil Wireless College
R.A.F. and Civil Navigation College
R. A. F. Engineering College
N. P. L.
Engine Manufacturers
R. A. F. Maintenance Units.
Works Technical Schools
College of Science
Research and Design
AERONAUTICS
Museum
Records.
Library.
R.A.F. Stations
POLYTECHNICS
External Degrees
Diplomas
and
Professions Civil Service
Universities
Engineering Schools
School Certificate
(and 'Higher')
Matriculation
TRADE, etc.
PRIVATE SCHOOL OR TUTOR 6-8
PUBLIC SCHOOLS
12 to 17 or 18 years
PREP. SCHOOL 8-12 years
School Certificate
Matriculation
SERVICES, etc.
Squadrons R.A.F.
R. A. F. Armament College
R. A. F. Staff College
R. A. E.
Civilian Repair Depots
Civil Airways Stations
SECONDARY SCHOOLS
11 to 17 or 18 years
PREP. SCHOOL 8-11 years
Imperial Defence College
Camberley
Greenwich
Airframe Manufacturers
Works Technical Schools
External Degrees
N.C., H.N.C. and Diplomas
TECHNICAL SCHOOLS
ELEMENTARY SCHOOLS
Senior 11-15 years
Junior 6-11 years
Infants 5-6 years
Junior Scholarship

will be high but opportunity for study and research must be given to men of ideas and specialised knowledge even though they cannot attain the standard required for admission in their general knowledge.

Attendance at the college will be the aim of all serious students of aeronautics, but owing to the secret nature of much of the information collected there it must be reserved for the British.

Until the various colleges and universities have established purely aeronautical courses of study the basic training of students will be engineering and the curriculum of the college will be designed to apply this knowledge to the intensive study of aeronautics. As time goes on the syllabus will require modification in the light of the growing knowledge of the subject already possessed by the students seeking entry.

In view of the transient nature of the syllabus it is difficult to lay down a definite course except to say that it will include aerodynamics, theory and design of aeroplane structures, theory and design of engines for aircraft, and mathematics, with the accompanying laboratory and drawing office work. Besides the purely aeronautical side there will be separate schools for the study of the higher branches of wireless telegraphy and telephony, navigation and armament for the benefit of the Admiralty, Royal Air Force and civil aviation, and fed by selected students from R.A.F. and civil aviation schools of the same nature.

In the chart the arrows indicate the educational progress of possible entrants to the college, while the double arrows signify the passage of information to and from the college.

F. Holliday (*Associate Fellow*) (*contributed*) : The following remarks apply to the recruitment, selection and training of apprentices in industry and to the co-operation necessary between education and industry.

(1) *Recruitment.*

The potentialities of industrial training schemes for pupil type apprentices are limited and will remain so while the headmasters of public and secondary schools continue their present policy of sending their best boys to universities, and not even the best of what is left to training schemes. This point should be "put over" to headmasters.

The action taken and the results achieved in attempting to ensure really adequate co-operation between the heads of secondary and public schools and aeronautical training schemes in industry have been inversely proportional to a rather high power of the considerable amount of vague talk about it.

Suggested: (*a*) The help and co-operation of the Board of Education Inspectorate should be obtained in " putting over " to the heads of these schools that good apprentice training schemes in industry warrant the attraction of boys of *the very best intellectual calibre* from secondary and public schools.

(*b*) The Headmasters' Conference and similar bodies—for example, the Careers Masters' Association—should also be kept informed of the desirability of this and it should be expressly pointed out to these bodies that the highest appointments in the engineering industry do not go, as a general rule, to men who have obtained a degree at a university; they go, generally, to boys of sufficiently good calibre who have completed a good apprenticeship, whilst at the same time pursuing a suitable course of study.

(2) *Selection.*

The systematic carrying out of a concrete recruiting policy is a necessary prerequisite to really effective selection. Boys should be looked for as pupil apprentices who have a *minimum* academic qualification of a " credit " in science and/or mathematics in one or other of the various school certificate examinations.

In view of the organised resistance in certain quarters to really intelligent and knowledgable psychological methods of selection and the complete inadequacy of the available training necessary for the application of such methods, it is unlikely

that the selection by the *aid* of psychological tests will grow very extensively in this country in the next few years, although this is likely to be "boosted" by the publications which will no doubt emerge as a result of the extensive application of psychological methods of selection and allocation at present obtaining in H.M. Forces.

Psychological methods of selection have sufficiently improved to warrant some considerable attention at any discussion dealing with the education of industrial aeronautical engineers and, at a time when the value of research is ostensibly being "boosted," there is every reason why the engineering institutions of this country, including the Royal Aeronautical Society, should "put over" to their members an unbiased picture of the evidence so far obtained as to the value of psychological methods. Remarks made at recent meetings of various societies and institutions to which this problem has come up evinced evidence of almost complete ignorance of the subject among engineers.

(3) The Royal Aeronautical Society or some such body should investigate and issue a comprehensive report upon apprentice training. This should deal with the foregoing, among other things. Steps should be taken to ensure that the position of training in industry is recognised to be of an importance equal to that of technical and production departments. The big industrial firms should, in fact, consist of training, technical and research and production departments. Unless and until this is done, training will continue to be very uneven throughout the industry and men will not be attracted as apprentice supervisors who have a really adequate works training and academic qualifications.

Every effort should be made, partly by means of the report just mentioned, to ensure an even and high standard of training in apprentice schemes and there should be some similarity of training. Identity of training is, however, quite undesirable.

Nothing would assist more in effecting the points mentioned in *Recruitment* above and in ensuring a high standard of training, than the recognition of the equal importance of training as compared with technical and production work, as expressed through the appointment of suitable apprentice supervisors, who should be in complete control of apprentices and who should be directly responsible to the management.

Workshop Courses in Production Engineering Generally.

Too little emphasis has been placed on the training of the craftsman, both from the point of view of his education and from the point of view of his works' training. Both these matters should receive the importance they warrant in any consideration of training in the aircraft industry. Also the education offered to pupil apprentices of good calibre has frequently been far too technical in the past, with the result that good material has been guided almost exclusively into technical jobs, where the pay is relatively small and the prospects relatively slight. More attention should be paid to envisaging definite schemes of training, both educational and works, with the intention of attracting some of the best calibre pupil apprentices to stay on the production side of the industry, which, generally speaking, is likely to lead to higher administrative jobs.

From the educational side, this should involve the systematic development of courses in production engineering, which are hopelessly inadequate in this country. The idea, in his opinion, that the intellectually superior apprentice or other boy training to be an engineer should only take a university degree, which is exclusively technical, is one that is certainly not calculated to put British industry on a firm basis.

J. L. Batchelor (*A.R.Ae.S.*) (*contributed*):

Suggestions for Training Aeronautical Engineers:—

Section I.

Those between the ages of 16 and 17 should possess matriculation or school certificate, or second year national certificate.

Those between 17 and 18 should possess higher school certificate or Inter-B.Sc., or third year national.

All of the above should attend one whole day or two evenings a week at a technical college, and be prepared to become Students of the R.Ae. Society preparatory to taking the Association Fellowship Examination at the appropriate age. They should, at the termination of their apprenticeship, have taken their final B.Sc. or the higher national certificate.

Those who start their apprenticeship between the ages of 16 and 17 will complete the whole of the four-year course before the normal end of an apprenticeship at 21. Those who start later and have shown the ability, etc., will be probationary technical assistants, and no doubt in parts of the four-year course the time spent could be lessened, as it would also be in the event of one of the 16 to 17 boys showing ability and desire to specialise on one side of the aero engineering.

Practical Training.

For the first nine months of the first year of apprenticeship, training should take place, when possible, in the engineering workshops of a technical college, such as exist at Derby, Loughborough, Coventry, etc., where the student can have a comprehensive machine training without interfering with production, and during this period he should be able to make for his use later on various small tools, such as calipers, squares, and scribing blocks.

During the next 15 months he should be engaged in the following shops in the engineering shops of the firms:—

	Approximate Period.
Material test	2 months
Pattern shop	2 ,,
Aluminium and iron foundries	2 ,, each
Die casting	2 ,,
Drop forge	1 month
Hardening and/or plating	2 months (or 1 each)
Toolroom	2 ,,
For the third year of his training at the works:—	
Chemical laboratory	3 months
Electrical laboratory	2 ,,
Supercharger development section	3 ,,
Carburetter and boost control section	2 ,,
Engine erection, etc.	2 ,,
Fourth year:—	
Engine test beds and hangars	4 ,,
Installation at aerodrome	4 ,,
Drawing or design office	4 ,,

Any apprentice showing exceptional ability and desire to specialise on particular subjects should be given the opportunity, even at the expense of the time allotted for other subjects.

Section II.

During the fourth year of his training, subject to his character and ability, he should be promoted to probationary technical assistant.

At the end of his training with the firm, a system of exchange between aircraft and engine firms should exist, whereby an apprentice on either firm could go for a further six months of training with the other firm.

Three main differences with this method of training engineering apprentices. *Firstly* that the whole of the machine training is carried out at a technical college with every facility for the basic training for machine and fitting instruction, giving every possible help to the apprentice to become fully competent in the shortest possible time, and not hindering production.

Secondly, the promoting of him to probationary technical assistant is conducive to the acceptance of responsibility and clarity of mind for administration at some later date in his career.

Thirdly the system of loan or exchange is very important for both firms and apprentice. Normally if an apprentice has shown real ability during his training, the firm are loath to part with him, nevertheless this is one of the most important parts of his training, for he learns more about the other side of the profession, and gets experience of other people's methods. It takes the place of the "journeyman" period that still exists to some small extent. The firm could protect itself by stating in the apprentice indentures the usual clauses about binding, etc.

J. G. MACKIE (*Sergeant Technical Instructor R.A.F., Associate*) (*contributed*): Many crashes and failures in the Royal Air Force at the present time are put down to faulty serving and maintenance on the part of the ground staffs, and this latter is too often thrown back on the instructional methods and instructors.

This, to a certain extent, may be justified, but the root of the trouble is to be found in the following factors:—

1. Method of recruitment of technical instructors.
2. Conditions of service and work.
3. Training policy which is dictated by people who lack actual practical experience and instructional experience.
4. Lack of co-operation between technical training command and other commands.
5. The type of trainee.
6. Technical training syllabus.

1. Many instructors are ill-equipped psychologically for the work, and are not particularly interested in instructional work. A careful selection from volunteers should be made, and attention paid to actual practical experience in maintenance of aircraft and also any previous teaching or instructional experience. Volunteers should be called for from the various trades, and with a rank of at least L.A.C. Other things being equal, preference should be given to ex-teachers, since they are already fully trained in teaching technique and have the temperament which is so essential to a good instructor.

Technical training schools should be combed with a view to eliminating unsuitable instructors and also instructors who prefer squadron work to instructional work.

Many instructors at present lack practical experience, having no previous engineering experience prior to joining the Service, being trained as a flight mechanic, then immediately afterwards being trained as a fitter, and followed straight away by a short course on instructional technique.

2. *Conditions of Service and Work.*

Instructional work should be put in a separate trade group (non-combatant if desired). Under the present system there is officially no such person as an instructor, he is a tradesman, and is paid according to his rank and trade, and his promotion follows according to vacancies in that particular trade. This system offers little incentive to instructors or shall we say "personnel engaged on instructional work."

Instructors should be free from the rank system, except in the case of probation which might extend for from one to two years. In place of rank, a distinctive uniform or badge might be employed. This would obviate the constant cry about promotion of instructors as against squadron personnel. Numerous cases have arisen where trainees straight from civil life, without previous experience, have been trained as fitters, and are now sergeants and flight-sergeants on squadrons, whilst their instructor who was perhaps a corporal (with years of experience) when they were trainees, is now junior in rank to his ex-trainees through no fault of his own.

Pay should be standard for all qualified instructors, with increases for number of years experience, or an increase for each phase the instructor has had actual instructional experience in. Obviously an instructor is worth more if he can take three phases rather than one.

This would cut out the injustice of instructors of different ranks doing exactly the same work for different rates of pay; and would act as an incentive to instructors to change around to different phases and so take a keener interest, and as a mental tonic.

The policy of recruitment and service could be continued in post-war years, and selected instructors induced to continue under a superannuation or service pensions scheme. The field could be widened by co-operation between the Royal Air Force, Royal Aeronautical Society, Board of Education and Manufacturers. A standard could be set by these bodies, and some form of certificate issued, stating that the holder possesses the necessary practical, theoretical and professional qualifications for teaching aeronautics both inside and outside the Service. In this way a uniform standard would be maintained and instructors would then be able to take up appointments in the Service or in civil life. It is not intended that such instructors should give tuition to men aiming at a degree and the higher posts in aircraft, but rather to the large numbers who will be responsible for the maintenance of aircraft.

Instructors should be kept up to date by visits to airfields, factories, and if in the R.A.F. by attachment to squadrons for definite periods.

Little thought and consideration is given to the fact that instructors are under a mental strain all day. Due allowance should be made for this by relieving instructors of all but instructional duties, since he cannot give of his best after working all day and carrying out other duties after working hours. This is reflected in his work and subsequently in the trainee.

3. *Training Policy Dictated by Inexperienced People.*

The station commander of a technical training school should, if possible, have had recent experience on an operational unit. In this way he knows what is expected from a trainee when he finishes training and is posted to a unit.

Schools should be run by commissioned technical training instructors rather than engineer officers, since the latter are apt to treat training schools as workshops and to organise them accordingly, to the detriment of instructor and trainee. Since instructional work is highly specialised, commissions should be granted to instructors as such, preference being given to instructors who have had practical experience on squadrons, plus a number of years experience actually instructing or teaching. Again the number of phases or subjects experienced in should be taken into account.

Phase supervisors should be commissioned, and be responsible for their phase, and should confer with instructors on suggested improvements, and give advice where necessary.

Instructors should be encouraged to give suggestions.

An officer of the rank of flight-lieutenant should be in charge of each trade with a senior technical training officer of senior rank to co-ordinate all trades in the school. In any school in civil life the headmaster must be a qualified teacher and his staff must be qualified; surely it is only common sense to apply the same sane and sound principles to training schools in the R.A.F.

4. *Lack of Co-operation.*

Several commissioned instructors (changed periodically) should act as liaison officers between training schools and operational units, e.g. one from each school per command, bomber, fighter, etc. These officers would travel round the various stations in the command, including overseas, and get to know exactly what is wanted by them, and expected of a trainee when he passes out. This would enable first-hand information to be passed on to technical training command and

schools; also, by periodic visits to the schools to ensure that they are kept up to date. In addition to frequent change of liaison officers they should be changed round the various commands. These officers should prove invaluable in post-war years, and the best should be selected and granted permanent commissions and permitted to hold air rank.

5. *Type of Trainee.*

At the present time when trainees are not specially selected, many different types are met with and instructors are too often tempted to class all alike and to treat them accordingly. Some, due to their previous occupation in civil life, are quicker to absorb theoretical knowledge but are not so inclined towards practical work. Others, again due to civilian occupation or age, are not so inclined towards theoretical knowledge but are handy when it comes to the practical side. It should be possible, with beneficial results, to roughly divide the various types before they commence training and to continue this process during training. In this way the various types would be treated according to absorbability.

6. *Training Syllabus.*

Following from the previous head, a syllabus should be devised which would aim at a more efficient tradesman no matter what his mental or practical ability. Trainees at present are too often classified according to their mental standard, and it is possible for a man with a very retentive mind, but practically useless at other things, to attain a higher rank when passing out.

Many trainees due to intensive concentration, become discouraged, with a consequent loss of interest, before they have finished their course. A remedy may be found in a simplified course or by giving a partial training at schools and not awarding any rank until a satisfactory course has been completed on a squadron. For example, a flight mechanic could be given a three-weeks' course on general fitting, a two-weeks' course on elementary internal combustion engines and one-week's course on aerodrome procedure. This would make a total of six weeks, after which his training could be completed at an operational unit, where he would be actually doing the job under supervision. At the end of this period he should be re-classified according to recommendation from both school and unit.

Technical instructors could be attached to the above units if necessary, where they could carry out supervision duties, and also keep up to date with modern aircraft and procedure.

After a period of satisfactory work on a squadron, flight mechanics should then be selected and sent to a training school to be trained as a fitter and a distinctive trade badge awarded. This trade badge would act as a great incentive and have a psychological effect, and surely the men who keep the aircraft in the air possess just as much a special qualification as the men who fly in the aircraft.

Finally, the syllabus should be drawn up by instructors, liaison officers, technical training officers and technical training command.

R. M. Clarkson (De Havilland Aircraft Co., Ltd.) (*Fellow*) (*contributed*): He fully endorsed Dr. Roxbee Cox's and Prof. Duncan's remarks about the importance of teaching people how to write English. The ability of the average person to express himself clearly on paper is deplorable. He doesn't seem able to put himself in the position of the reader. Wing Commander Cave-Brown-Cave summed up this point rather well by saying that in many respects more difficulty was experienced in presenting the case than in evolving it.

He would like to suggest that the teaching of team spirit and the ability to understand and work in harmony with other people should receive some attention in the training of engineers.

There are a number of factors which require very careful consideration in connection with Sir Melvill Jones' proposal for a central aeronautical technical educational institution and indeed with any proposal for an expansion of technical educational facilities.

Supply must not exceed demand, the aircraft industry after the war—large though it may be—will be but a fraction of its present size, and all planning must be based on its estimated post-war requirements. The bulk of the engineers in the industry (planning and production engineers, draughtsmen, section leaders, skilled mechanics, etc.) require a general technical education in engineering fundamentals, the higher flights of research and specialisation are only needed for the firm's research personnel—a comparative minority. Most firms who have given attention to the training of their personnel have evolved their own domestic arrangements linked generally to a local technical institution for providing the general engineering technical training for their future engineers; they would not wish to go to the university or the proposed central aeronautical institute for the rank and file of their engineers, but only for their specialists—a minority.

This system of domestic engineering training which is practised by many firms has much to recommend it—the young engineer is within the orbit of the firm during his training, he assimilates the personality, ideas and traditions of the firm, and when the time comes for him to take up employment with the firm they have a very good idea of his ability and personal qualities. These advantages are lost in any scheme for the centralisation of aeronautical engineering education. He appreciated that for the higher grades of research workers and specialists the industry must go to the Universities, but these represent a small proportion of the whole, and any proposals for the expansion or centralisation of academic teaching must be related to the estimated probable demand.

In the present system of University training of engineers there is no guarantee that a man has had practical Works' experience—he can pass all his degrees without ever having been inside a Works and is thus incompletely trained for industry, even for a research post. Could not this be rectified by making the granting of a degree dependent upon the candidate having spent a high proportion of his vacations in a Works?

Educational institutions should make sure that their instruction is fully up to date with current industrial practice, to this end some closer liaison between educationalists and industrialists—possibly taking the form of refresher courses for the former—might be instituted.

He fully agreed with Wing Commander Cave-Browne-Cave's remarks regarding the importance of a good knowledge of fundamental principles, before specialisation.

More freedom for interchange of personnel between research establishments and the industry would be highly desirable. There is a tendency for the theoretical man to go into the former and the practical into the latter, and thereafter they are each ignorant of the other's problems and requirements.

He would like to see every clerk, typist and shop apprentice engaged by a firm given a brief course in Empire Policy and History, Citizenship, English, Co-operation, and the Firm's background, history, aims and achievements.

Group Captain NELSON (*contributed*): This problem requires careful consideration in view of the highly technical qualifications which will be necessary if aeronautical engineering is to reach the required standard necessary for designing, constructing and servicing the complicated aircraft already in and coming into existence.

He felt that there are two points fundamental to the whole question which will have to be settled:—

(*a*) What careers will be available for aeronautical engineers?

(*b*) What type of aircraft, both civil and military, is likely to be used in the future?

Many types of engineers will be necessary, such as

(i) Research Engineers.

(ii) Engineers (designers) with a Science degree other than (i).

(iii) Production Engineers.

(iv) Practical Engineers for supervision of complete flights of aircraft on airfields.

(v) Engineers with A. B. C. D., etc., licences for certifying air worthiness.

(vi) Flight Engineers.*

As regards (*b*) one can visualise that future aircraft will be much larger than those at present in use, so that the problem of training aeronautical engineers becomes of even greater importance than with the present type. Visualising aircraft of, say, 500-ton dead weight, then one must appreciate that the future of aviation will follow similar lines to that of the Royal Navy, *i.e.*, there will have to be large aircraft with ancillary smaller aircraft, dockyards, and much complicated equipment stores.

In order to meet these requirements, he would suggest that the personnel can be trained by means of an apprenticeship starting from the school leaving age (say, sixteen years). These apprentices would start their training in a similar manner to that employed in the past. They would commence a five-years' apprenticeship during which they would go through all the engineering departments. The best of these apprentices would be selected after, say, three years of their apprenticeship, and sent to a college where they would be trained to become aeronautical engineers as opposed to their initial training as mechanics. The selected apprentices would, of course, be those who had made considerable headway in maths. and mechanics by attending evening schools during their apprenticeship. This college course would be of two or three years' duration, and would deal with all aspects of aeronautical engineering. They would study aerodynamics, structures, theory of aeronautical engines, metallurgy, electricity, technical organisation and administration, mechanical drawing, etc. During this training period they would pass through the various laboratories. On the completion of the above course a certain number would be selected for further training according to their ability as

(*a*) Production Engineers;

(*b*) Research Engineers or Engineers (Designers).

It was, in his opinion, essential that all aeronautical engineers should have some experience in the air, not necessarily as pilots, but it would obviously be an advantage. In any case, before they are considered competent aeronautical engineers he was of the opinion that they should have completed approximately 100 hours' flying, either as pilot or passenger. (Research Engineers or Engineer Designers might possibly be in a category by themselves as regards flying. This type of engineer is, as a rule, only concerned with special aspects of aeronautical engineering, for instance, many Research Engineers are only concerned with the future, and have little or no interest as to how the result is applied to aeronautical engineering.

As regards the Flight Engineer, if the vision mentioned in paragraph (*b*) is a correct surmise of the future, then the Flight Engineer would have to qualify in a way similar to that in vogue for marine engineers. Bearing in mind that if this is correct, a certain amount of repair work should be possible whilst in flight, he would therefore require to be a first-class mechanic with a specific aircraft type knowledge and a sound theoretical knowledge to diagnose all the faults which might occur to the airframe, engine, hydraulic system, instruments, etc.

The question of Ground Engineers is, in his opinion, a class on its own, and they should do the apprentice course, and the next strata below those selected for the college course should be sent to a special course such as the De Havilland or Chelsea College of Aeronautical Engineering, in order to be trained as Ground Inspectors.

* The status of the Flight Engineer will obviously depend upon the answer to (b) above.

He suggested that the A.I.D. personnel should be similar to the same type if the system of A.I.D. inspection is still in use after the war. It may be that manufacturers would use their own personnel in the Inspection Department, but this would not alter the type of man required.

There are other types of personnel to be considered, *e.g.*, those who have been to Public Schools or Universities. Those from Public Schools should, he considered, be able to take up aeronautical training from a point where the apprentice is selected for theoretical training at the college. They would not have the advantage of a mechanical training, but they could utilise their vacation periods to make up a certain amount of this deficiency. University candidates should, he considered, join the University Air Squadron Auxiliary Air Force, if such is in existence after the war. During the period of their training at the University they should complete an aeronautical course and those most suitable should be selected for further training as Production or Research Engineers.

G. GEOFFREY SMITH (Managing Editor of " Flight " and " Aircraft Production ") (*contributed*) : Lack of facilities for the advanced training of aeronautical engineers and for research work generally has disturbed many. The aeronautical journals for years have been consulted as to existing facilities for technical education and regrettably little help could be given. There are Chairs of Aviation in one or two universities, which are excellent in themselves, but in view of the rapid growth in aviation, the immense possibilities ahead, and the certainty of international competition a great deal more is called for. The idea of a British University of Aeronautics was put forward in the technical and daily press to arouse public interest in the scheme supported by Mr. F. G. Miles.

It is hoped following this discussion that a recommendation will go forward to the Government from the Society, in association with the S.B.A.C., supporting the idea of bringing under one roof all the sciences and branches of engineering and technology directly or indirectly connected with aircraft. A national institution seems the best solution to this urgent problem. If, however, this is considered too ambitious, chairs of aviation should be established at all the leading universities up and down the country and opportunity provided for all students of aeronautics to attain a B.Sc. degree in that subject.

For the rest, more progressive aircraft manufacturers will no doubt expand and widen the scope of their technical schools, which individually have already done such excellent work in ensuring a continuing supply of technicians. Students in every walk of life should be given an opportunity of widening their technical knowledge. It is a national necessity for Britain to be equipped as efficiently as other nations with research apparatus, laboratories, engine test beds and wind tunnels demanded for continuous development.

RESUMED DISCUSSION.

The discussion on the education and training of Aeronautical Engineers was continued in the Lecture Theatre of the Institution of Mechanical Engineers, at Storey's Gate, St. James's Park, Westminster, S.W.1, on Friday, July 23rd.

In the chair, Dr. H. Roxbee Cox, a Fellow and Vice-President of the Society.

The CHAIRMAN : This was a continuation of the discussion at the meeting of June 25th at which a number of people had put forward some valuable and interesting ideas, while a number of others had contributed later to the written discussion. A report of the whole meeting, together with these written statements, was in the hands of many of those present. The discussion would be of value in bringing out ideas on this subject of education and training, but in order to have the greatest value he thought it was necessary that it should terminate with a resolution. He therefore desired to keep that in view during

the present discussion. He hoped that speakers would avoid going over the ground which was covered on the last occasion, and to assist towards that end he proposed as briefly as he could to summarise the discussion then held and to refer briefly to the written contributions, some of which had not been seen by members of the present audience. As some would remember, he himself had opened the discussion and had made the obvious points about the need of training the right number of people in the proper methods, and the fact that all branches of the industry had to be considered—designers, engineers and scientists, navigators, pilots and captains, and aircraft or ground engineers. Further, they had to ensure that the profession of aeronautics attracted a high proportion of people of high capacity.

Sir Roy Fedden had followed with an account of what was going on in America in regard to technical training at the present time. He had also referred to the apparent penalties of specialisation in the R.A.F., and had said that there was apparently a belief in this country that engineering training does not equip men suitably to take executive and administrative responsibility.

Sir Melvill Jones had spoken on the training of students of post graduate standard and had pronounced himself in favour of a school for higher posts of research in the industry—a school which would supplement rather than displace university training, and in which all who could learn to fly would be taught to fly. Its function would be to raise the standard of technical knowledge amongst all who had to occupy the higher technical and executive posts.

Sir Frederick Handley Page had asked that post graduate courses should be concerned inter alia with engineering production and administration and had emphasised the necessity for practical training.

Professor W. J. Duncan had commented on the views which he himself had expressed and said that the avoidance of specialisation could be carried too far. He strongly supported the view he (Dr. Cox) had put forward on the need for teaching people to express themselves in English, and Wing-Commander Cave drove this point well home.

Mr. Ferguson had stressed the need for further training for all sections of the industry and had referred particularly to the training of those people who were engaged in mechanical processes. He had made the point that it was impossible to divorce aircraft engineering from general engineering.

Mr. Petter, discussing the supply and demand of engineers and technicians, grouped them in effect into skilled mechanics, a small group leading the technical and manufacturing departments, and the group of technical men intermediate between these. He was particularly concerned with the desperate shortage in the second group, in which were assistant designers, section leaders, planning engineers, progress engineers, and so on.

Group Captain Williamson had suggested that the Government should investigate the number of apprentices to be taken into the industry and how they should be distributed amongst the factories. He had also asked for the use of intelligent methods of selection.

Mr. Thomas had emphasised the need for training the men responsible for the maintenance and airworthiness of aircraft, really part of Mr. Petter's first group.

Sir Lindsay Everard had proposed an Aeronautical University, his view appearing to be different from that of Sir Melvill Jones, though he (Dr. Cox) was not sure that in essentials it would prove to be so, because even if a large training organisation were labelled "Aeronautical," a tremendous amount of the early training would inevitably be of the general kind.

Mr. Miles had supported the Aeronautical University idea, but made it clear that the University, true to its name, would provide a broad training and indicated that specialisation should be deferred to the later stages of the courses.

Wing-Commander Cave-Brown-Cave spoke in favour of specialisation being deferred as long as possible.

That was a very rough and inadequate summary of the spoken discussion. Then came the written contributions which had been published in the report of the proceedings. Mr. T. G. John deplored the absence in the aeronautical industry of sufficient potential leaders and thought that not enough attention had been paid in the past to selection, including selection of teachers. Management had not been well organised so as to bring the best out of people. On reading that he felt that his own point again came into prominence, namely, that potential leaders must also be attracted to the industry.

Mr. C. H. Roberts also mentioned this need for attracting the best type of people to put forward a scheme for an aeronautical training centre working in collaboration with the Universities, the aircraft and engine manufacturing companies, the air transport companies, and with the public and secondary and the technical schools.

Professor Sinnatt had brought forward a still more detailed scheme of a not dissimilar nature.

Then there were various other carefully thought out statements which should be studied with great care. These were by Mr. Holliday, Mr. Batchelor, Mr. Mackie, G./Capt. Nelson and Mr. Clarkson. The statements dealt with selection, investigations into apprenticeship systems, and proposals for practical training courses. They dealt also with the recruitment, training, and personnel of the R.A.F. Mr. Clarkson had emphasised that it was necessary to plan the estimated post-war requirements and strongly supported the views which others had expressed on the need for a command of the English language and a knowledge of the fundamentals of science before specialisation.

His own assessment of this valuable body of material was that the majority opinion was as follows:—

(*a*) There should be expansion and co-ordination of existing facilities.
(*b*) There must be provision for training men and women for all sections of the industry.
(*c*) There should be created an aeronautical centre complete with aerodrome for higher education and training.
(*d*) This higher training must not be directed only to research, but must include the more advanced aspects of production, maintenance, flight testing, administration, and the co-ordination of them all.
(*e*) There must be close liaison between all local, technical, commercial, university and firms' training organisations, and the central school.
(*f*) In planning education and training, the importance of education in fundamentals and in the use of English must be reflected.
(*g*) Steps must be taken to improve the status of the aeronautical specialist.

Put in that brief manner, it over-simplified what was said on the last occasion, but he thought it gave the general trend of the discussion. He proposed to call first upon some members who had had no opportunity of speaking on the last occasion, but he intended ruthlessly to close the discussion in good time because he wanted a resolution to be put to the meeting and this might entail further discussion.

Professor F. T. Hill (Imperial College of Science and Technology) (*Fellow*): He would try to keep to the Chairman's instruction and avoid repeating anything said on the last occasion, the more so because he had all along intended to take up quite a different line. He could not help being struck at the last meeting by the fact that practically nobody mentioned what was in existence at the moment, and his purpose was to recall it to their attention. It was just as well to consider what they had now in the shape of educational and training provision and see whether they could not build on that rather than bring forward

something quite so revolutionary as was suggested at the last meeting. He had found very often that persons intending to take advantage of aeronautical educational facilities, both students and employers, had no very extensive knowledge of what was available. He trusted that the present conference might serve to widen that knowledge as well as provoke constructive criticism of the general scheme now in existence.

The first thing to tackle in promoting a scheme of education for any particular profession was to find out what knowledge was required for an entrant. When this was established, responsible bodies should draw up a series of syllabuses, the specification as it were, for a man qualified in that profession, and hold examinations in them. Once these were established, it was the duty of teaching bodies to organise training for them as their local circumstances demanded. This had been done with considerable thoroughness in the aeronautical world. Examinations were available covering all types with very little overlapping, and were being administered with a commendable degree of collaboration and lack of jealousy.

Type of Work.	Profession.	Examining Body.	Teaching Body.
Repair and Maintenance.	Ground Engineers.	Air Ministry and Air Registration Board.	Works Classes.
Construction.	Shop workmen, charge hands, foremen, etc.	City and Guilds Technological Dept., Aeronautical Engineering Practice.	Municipal Technical Institutions.
Works Administration and Design.	Shop or Engineering Apprentice.	Special Diplomas.	Works apprenticeship+ organised classes such as College of Aeronautical Engineering, Chelsea, De Havilland, Bristol Aero Co.
		Higher National Certificates or Diplomas with Aeronautical subjects.	Municipal Technical Institutions.
Design and Experimental Work.	Full-time Student.	R.Ae.S. Associate Fellowship or Special Diplomas.	Special College Courses, usually sandwiched systems such as the Hull or Loughborough Colleges.
		University Degree with Aeronautical subjects.	Various universities.
Research and Experimental work.	Post-graduate Student.	Higher University degrees in Aeronautics.	London University (Imperial College).

They could be summarised as shown in the diagram* which showed the type of trainee envisaged, the responsible examining authority, and the kind of Institution assuming responsibility for the training.

He suggested that this was a well-thought-out foundation covering the profession in all its branches, and it could form the base on which to build an educational scheme capable of practically any expansion. He felt that the technical educational world might well be congratulated on it.

Expansion of this scheme could be made to cover practically all that was called for at the first meeting, with the possible exception of the special training of experimental and research workers envisaged by some speakers. It was not easy to see exactly what those speakers had in mind. Research could not be taught in the ordinary way. If a student had an original and critical mind with

proper training in the fundamental sciences of his chosen profession, he could acquire competence in research only by experience under a senior research worker. He would, therefore, suggest that the present scheme might be extended by creating a class of student research workers at the Air Ministry and D.S.I.R. stations. Such persons, after graduating, would be employed in the usual way, but taken on for only a limited period, say three years, after which they would be considered to be qualified for research or experimental work. Facilities for this type of training could be extended if the industry had its own Research Association with appropriate equipment.

When they came to the response to the existing schemes by entrants to the profession of aeronautics the position was not so happy. The numbers submitting themselves annually for this " measuring up " were remarkably small when compared with what must be a vast total employed in the industry to-day. It was true to say that, except for the National Certificate, candidates at any of these examinations can be numbered in no more than tens. With the National Certificate the numbers, while they were probably over one hundred annually at present, they certainly did not reach the two hundred mark. Moreover, these figures included a good number of R.A.F. personnel who had such courses specially arranged for them at various centres.

He suggested that the possible causes of this lack of response might well be a subject of debate at that conference.

One complaint which was often heard, in fact it had been made many times to that Society, was of the lack of facilities for obtaining teaching, no classes being held in certain centres. If this was true the remedy was obvious, at least in those cases where local education was in the hands of the Municipal institutions. The local aeronautical firm, as a large ratepayer, had the right to demand that a due proportion of the higher education rate should be devoted to the teaching of his speciality. In his experience, local authorities, backed by the appropriate department in the Board of Education, were always only too willing to co-operate. The governing bodies of Universities were also always sympathetic to pleas for specialised education needed in their particular province. They were usually only too anxious to keep abreast of the times in such matters.

Another possible cause was that the conditions in the industry, both as regards salary, security of tenure, and the number of appointments likely to be available, were not sufficiently attractive to induce the numbers at present in the industry to wish to remain in it after the war, or to attract the parents of the young men coming along. The aircraft industry demanded a very special knowledge of most of its employees, and must be prepared to pay for it.

Another reason for this lack of support might be that the industry as a whole did not agree with the curriculum, and therefore did not advise young men to take it up. He could hardly think that that was so, as they had opportunities of sitting on the various advisory committees that controlled these schemes, and the channels through which they could express their dissatisfaction and give effect to any other suggestion, were always open; in fact, their advice would always be welcomed.

When closing the first meeting the Chairman had asked that concrete proposals should be put forward at the resumed discussion. He would suggest that this meeting should pass a resolution calling on the Society to endeavour to resurrect the scheme which was put forward by them in 1937, as mentioned by Sir Roy Fedden in his opening remarks. This scheme would put apprenticeship with suitable theoretical training on a properly organised basis, and would result in an immediate increase in the use of the facilities already in existence. If such a scheme were properly known to the general public it would attract a good class of entrant to the profession and ensure a continuity of supply.

Further, he would also suggest that the meeting asked the Society to press for the introduction of student research workers as mentioned earlier in his

remarks. This would round off the apprenticeship scheme by creating a definite opening for the type of trainee who had, by that time, shown that he had the type of mental equipment necessary for such work.

On July 14th, the morning following the debate in the House of Lords on the future of aeronautical education, the *Daily Telegraph* gave a leading article on the subject. Amongst other things it said: "At the present time education and research over the whole field of aeronautics are, to put it mildly, almost unorganised." He submitted that these remarks were an answer to the statement, which was, "to put it mildly," a considerable exaggeration. Incidentally the same article went on to say: "The Universities possess only one professorial chair and that has so far been in abeyance." There were three Chairs of Aeronautics in this country, at Cambridge, Hull, and London Universities. He was not sure to which the writer of this article was referring when he described it as being "in abeyance," but certainly London was functioning fully, and had been so throughout the war, in fact, without interruption since 1920. That in spite of certain determined attempts by the Ministry of Labour and National Service to close it down in the general interests of recruiting.

Mr. M. LANGLEY (Flight Refuelling, Ltd.) (*Fellow*): Professor Hill and himself were very old friends, but he could not let the occasion pass without drawing attention to one or two points on the chart which Professor Hill had shown and with which he disagreed. In the case of shop or engineering apprentices Professor Hill's chart indicated that they should be trained in such places as the College of Aeronautical Engineering, Chelsea, the de Havilland Aeronautical Technical School, and so forth. He himself would have put such places as these in the next broad column for full time students engaged on design and experimental work. Many of the students of Chelsea College and of the de Havilland School passed out on the level of Associate Fellowship of the Royal Aeronautical Society, which led them straight into the design and experimental work. From another point of view he disagreed with Professor Hill, namely, as to a feeling of complacency about what was already in existence. It seemed to be suggested that here was a scheme, a very good scheme, and the only question was, why was it not used? The mere fact that meetings of the present kind were taking place not only in their own Society but in other Institutions concerned with this problem—crowded meetings—to express dissatisfaction with existing educational schemes showed that something was lacking in the present arrangements. It was not only the problem of what happened to the student when he had finished has training. The problem was how to give him a better training than he was getting at present.

As to the kind of man they wanted to train, he thought that the whole of the aeronautical engineering trade or profession must be included, as well as the specialist people, whether design for research work or for the more skilled grades in the factory, performing operations there which were not common to the whole of the engineering industry. There were certain forms of press work, certain heat treatment processes, a number of processes concerned with corrosion protection which were not to be found in general engineering and these must be dealt with even if one did not specifically deal with such universal operations as drilling.

What was the number of people who would have to be trained? New data had been brought forward, and he would like to suggest some figures of his own. His guess was that in pre-war days there were probably 5,000 technical people—stress men, draughtsmen, and men engaged in skilled operating and specialist manufacture in the aircraft industry. They had to remember that the membership of their Society was about 2,500, and they could go round to the various drawing offices and find very few draughtsmen who were members. That was a criticism, not of the draughtsmen, but of the Society. If one doubled or trebled this 5,000 for post-war purposes and allowed an average life of thirty

years per man in the industry it meant an annual input under stable conditions of 300 to 500 per annum. Allowing for five years training, this meant that a total number of between 1,500 and 2,000 would be in training at one time. It was that number which decided the kind of institution they would have to provide.

The CHAIRMAN: Did these numbers include draughtsmen and technicians?

Mr. LANGLEY: He was talking of specialist manufacturing people—ground engineers, and so on—the kind of people who should be members of their Society as Fellows, Associate Fellows or Associates. He said, " those who should be," not " those who are."

If this was the number to be accommodated—and he was open to criticism on the subject—it could be decided whether it should be dealt with by existing methods, as shown on Professor Hill's chart, or whether some other method or methods should be used.

He would be very bold and say that the university system was far from satisfactory. So far from giving a wide training as had been claimed, he suggested that it gave far too narrow a training for developing the aircraft engineer, unless, indeed, it was bolstered up by a considerable amount of workshop practice. But the University did not lend itself to co-operation with industry. It was rather the case of the shopkeeper telling the customer what he must buy.

Equally, one must be dissatisfied with the apprenticeship-cum-technical institute method of training because it implied in its present form that the student must do a hard day's work in the factory and then, when tired out, study under a lecturer in the evening, the lecturer probably being as tired as himself.

So much for destructive criticism. He wished to be constructive too, but in being so he was not going to be revolutionary. He desired to suggest a recognised educational method which so far had not been mentioned in the discussion but which had produced many brilliant engineers. He referred to the Naval Dockyard method. The system was as follows: That apprentices, students of all grades, started on the same level and went through a four years' apprenticeship in which a technical class and lectures, theory and practice, were inextricably mixed. The student was always in a position to study the theoretical idea behind the practice and the practical applications of the theory.

At the end of each year, or perhaps more frequently, the students were sifted out and went forward on more specialized lines in their particular bent. It was really a psychological test. This went on for four years, and at the end of that time the student was not only a good engineer practically, but he had a good theoretical knowledge up to university standard, and the two had been acquired simultaneously. After this, the more brilliant of them were given the opportunity of going through the Royal Naval College at Greenwich, and he believed the course there was three years. That was the system as he understood it, and he thought it was a very good one, and there had been very little criticism of its products. Its products were to be measured by the results in the form of ships. He suggested that this was an arrangement on which the training in aeronautical engineering might be based. He did not know whether the number of students who went into the dockyards approximated to the number he had just mentioned. In aeronautical engineering they should be divided up amongst the major aircraft constructing and operating firms. He underlined the words " and operating." Each firm should take its quota of students and the students should be sifted into their appropriate grades where they could best develop their native skill, whether mental or manual.

This scheme would have to be co-ordinated on a national basis and its products to be recognized at the end of the training by some standard qualification such as the Associate Fellowship of that Society. It was a much bigger scheme than that envisaged in the early pioneer days of the de Havilland Technical School. That

School might be taken as a model, the training increased from 3 years to 5, and include in the training much more science than was given in his own time. It would be necessary also to reduce the fees to a figure which would allow any boy of merit, whatever his financial ability or social background, to take advantage of it.

Mr. D. L. Ellis (Vickers, Weybridge) (*Fellow*): From some of the observations made in the discussion it appeared that the training of the aeronautical engineer was going to require at least ten years. The industry was so young that it was not yet known what branches of technical knowledge would eventually be drawn on, but up to the present an aeronautical enginer must also be at least a good civil and mechanical engineer, a physicist and a mathematician in addition to his specialised training. Clearly few people could afford the time to cover such a course thoroughly, so some form of sub-division appeared to be necessary.

However, he would suggest that whatever happened the general engineering part of the training should be the last to suffer. One of his reasons for this argument was that although the majority of people engaged in aircraft design to-day had started in other branches of engineering yet our technique of construction was in many respects poor when compared with those other branches: he felt that if we had men trained only in the aircraft world we might become worse still. He would also suggest that the student should spend part of his practical training in, say, the mechanical or electrical engineering industry.

Another respect in which aircraft design differed from other branches of engineering was in the very big gap which existed between the development of the theoretical side and the practical problems which had to be faced. A man well trained in mathematics and theoretical aerodynamics could only tackle a small proportion of the problems met in aircraft design. The remainder had to be solved by other methods which had a technique of their own. This suggested two separate courses of University training: one for the student with the aptitude and inclination for research, who would concentrate on the mathematical and theoretical aerodynamic side and would, of course, have a general knowledge of the designer's problems. The other would cover the remainder of the subject but would include a knowledge of what could be done by the advanced theoretical side.

Mr. K. R. Imeson: The subject of schools had cropped up in that discussion and he wished to raise one or two points from the school angle. Liaison between the schools and the engineering industry was undoubtedly necessary, and in this connection he had one or two concrete suggestions to make. The R.A.F. had sent round to the schools once or twice a year an officer to interview candidates for air crew duties in the R.A.F., and it was remarkable what success they had had in picking the right type of boy and in giving him attention. He suggested that either the R.Ae.S. or the industry itself should send experienced men to the schools, perhaps once a year to each school, in order to give a talk to the boys and afterwards interview those who were particularly interested in aeronautical engineering. These boys were likely to be very ignorant of what happened when they took up such a career, as also were the schoolmasters themselves, so that it would be extremely helpful if experienced men with a knowledge of the industry could give these boys advice. He would not suggest, as another speaker had done, that a Board of Education official could fulfil this "function," as he had not the necessary knowledge of conditions obtaining in the industry.

Another suggestion was that even in the schools contacts should be made with local firms. He had himself initiated a scheme whereby two boys from the school in which he himself taught had a month's training with an engineering firm during the summer holidays. They spent that time in going through every branch of the works and undoubtedly gained something of practical value.

In some cases mathematical specialists had taken advantage of this scheme and it was hoped that the experience gained would assist the future co-operation of the mathematician and the technical man, and help them to understand each other's difficulties.

Secondly, he wanted to make a plea for general education at the secondary school after the age of 16. Several engineers in the present discussions had frowned upon that. Others, like Wing Commander Cave-Browne-Cave, had recommended that before embarking on a career in engineering, boys should have a sound knowledge of the English language, and in particular the power of lucid expression, which was not necessarily achieved by the passing of the School Certificate. They should not specialise too early, and if they stayed on at school after 16 they could develop a sounder basis or scientific and mathematical knowledge, combined with a broader outlook than they could possibly achieve by intensified study at evening schools on a narrowly specialised syllabus. Many evening school pupils had the aptitude and the desire to go beyond the prescribed limits necessary for examination purposes, but they had not the time nor, after a hard day's work, the energy to develop their natural abilities along broader lines.

A plea might also be made for the few individuals at the secondary schools who were outstanding mathematicians. Engineers too often seemed to want to take all the best boys at school and make them apprentices, starting at 14. He thought that was a mistake. The research workers were needed for the industry. He knew that one gentleman in the former discussion complained that headmasters sent their best boys to the University. That was only natural, because for the academically gifted boy the University developed his powers to the best advantage. A boy with a special gift for mathematics would proceed to a University and receive a broad comprehensive training in mathematics, in which the various topics studied would not be limited to those with some special bearing on his future work. In his view, the man was likely to be valuable to the industry, because he would bring a fresh and individual outdlook to bear upon the problems put forward by the experimentalist. He might mention one way in which this type of mathematician had proved his worth. The science of statistics was of ever-increasing value in engineering to-day and yet it was only comparatively recently that this subject had been " applied " to industry. As Wing Commander Cave-Browne-Cave had suggested, aeronautics had developed rapidly in most unexpected directions, and it had become increasingly necessary to have available the fully trained mathematician to deal with these unexpected developments and to solve the attendant problems set by the experimentalist.

Mr. H. YENDALL (*Associate Fellow*) (Bristol Aeroplane Co., Ltd.): In his company they were engaged on the study of the question of apprentices and were proposing to send a qualified engineer round to the schools, secondary and public, to talk to the boys and tell them about the conditions and prospects. What was more, when the boys were selected they would come to the works for an interview and be taken round before they made up their minds that they wanted to go in for aeronautical engineering. He had been studying the question of the education of apprentices and engineers for some little while, and he wished to see in being the two schemes which had been proposed, namely, the University scheme and the scheme of a research centre with post-graduate education. He desired to see the post-graduate centre include within its purview factory management and planning and production, and he would also like to include flying. Some of the things which he had found out when having flying experience had been most helpful to him.

As for the individual chairs, there were three of these at the moment. He would like to see a few more, and to see the chairs located in the factories themselves. One of the big problems was the cost of the necessary accommodation. He suggested that some of the leading firms when they considered their post-war planning and building and so forth, should entertain the suggestion of allocating some of the buildings which might be spared for that purpose. They might also arrange occasions for the teaching of specialist subjects—aerodynamics and so forth—by specialist members of the firm's staff. The education would be right up-to-date and the lectures could be given to the students as easily as passing over to another department in the firm. The students also

would be right in the midst of the industry, instead of pursuing their studies perhaps far away from an aerodrome and seeing nothing of flight. He desired to see students on a graduate course doing part-time in a factory with courses planned by the firm's educational officer. He desired to see them going from the secondary school and putting in one year in the factory before they went on to the University. Their three years in the University should probably be followed by another 18 months in the factory, following whatever subject for which they had a bent.

So much for the University men. Then one came to the young men who were going to leave the school under the new White Paper proposals. They were coming away with a secondary school education. He was assuming that they would have a School Certificate. They would be engineering apprentices. He desired to see them taking a five-year course in the works and also attending day technical college. Such a scheme as this had been running in a small way in the Bristol Aeroplane Factory (as distinct from the engine factory, which had its own school). He and his colleagues did not believe in night schools for training any more than could be helped.

Professor Hill had covered one or two of the points he intended to make. He desired to see a higher National Certificate on aeronautical subjects. He stressed also the point about writing English. It was really amazing to discover how few people belonging to the large technical staffs could put together a concise letter or report on a technical subject.

To the ordinary apprentices he would like a proper training room assigned when they first came to the shops. They should not immediately be turned over to the tender mercies of the foremen, whose only object was in many cases to get production. In a North Country establishment they had a training room in which apprentices spent two years before going into the shops. There was one matter on which he wished to lay further stress, namely, that the firms must make the careers prospect brighter, with regard to status and salaries of technical staff. A medical or dental student who had spent five years on his course came out at 23 and immediately got ten or twelve guineas a week as an assistant. What were we paying our engineers? Nothing like so much.

Mr. A. C. CLINTON (Bristol Aeroplane Company) (*Associate Fellow*): During the later stages of training, students should have the opportunity of visiting factories in this country and abroad. Teachers also should have facilities for visiting other schools and universities for refresher courses, and should spend some time seeing the practical development of their instruction in experimental and production establishments in this country and abroad.

When the Council considers the proposals of the meetings and draws up the scheme, there should be close co-operation with the education authorities in the Colonies and Dominions, and representatives should be invited to England to collaborate in this work. It is equally necessary for two or three representatives of the Council's Committee to visit Australasia, South Africa, and Canada so that they may see at first hand the existing facilities and learn something of the Empire requirements, since these have not been sufficiently well known, or considered, in the past. This interchange of visits should be arranged during the next two months.

In considering the collaboration with the Empire, it is suggested that contact should be made with the Empire Central Flying School at Hullavington, which has been developed to co-ordinate schemes of training, and to foster and preserve British influence throughout Colonies and Dominions in most matters relating to aeronautics. Air Commodore Oddie is in command of the Station, and the Chief Ground Instructor is Wing Commander Kermode, a Fellow of the Society. A large number of experienced and influential officers from Australia, New Zealand, South Africa and Canada pass through the course during the year, and every endeavour is made to bring them into contact with all aspects

of military aeronautics and as far as possible with the aircraft industry and experimental establishments.

Referring to Professor Hill's opening remarks, the speaker strongly supports his proposal that the training scheme put forward by the Society in 1938 should be reviewed and if necessary modified in accordance with the views of the meeting, and submitted again.

Professor Hill referred to the training scheme at Bristol, and this is the one in operation in the Engine Division. He wished to point out that since the beginning of the apprentice scheme many years ago, the company have never made any charge for training. The boys have always been paid from the time they joined the company and their rates increased progressively according to their age and work. Further they receive free tuition (part-time day course), up to and including Ordinary National Certificates in mechanical engineering.

The Bristol Company realised that it would be difficult to attract the right type of technical instructor if remuneration was based solely on the Burnham Scale. After careful consideration, therefore, they instituted a scheme so that the instructors, whilst retaining their position on the Burnham Scale, would receive additional payment in lieu of (a) long holidays and (b) short working week which could not be granted in industry. The increase accruing from the above arrangement certainly made the post of instructor more attractive, and has proved satisfactory in practice.

As mentioned by Professor Hill, they believed in close collaboration with the local education authorities, and their educational staff are an approved body of the Board of Education, and can conduct their own examinations for the National Certificate in engineering. Prior to 1939 their apprentices took their examinations at the local Technical College, but since that date there has been an increasing number of apprentices passing the Ordinary and Higher National Certificates, and this year 30 Higher National Certificates have been gained.

Referring to Mr. Langley's remarks, a considerable amount of sifting is taking place all the time in their Apprentice School. In the company they had about 800 juveniles, and of these about 640 have contact with the school. There is a probation period for all boys entering the school, and they are started and progressed according to their ability. Some of them do not get very far, and throughout all the grades they found there was need for periodical adjustment, and at times they have to be ruthless in advising lads what they should do.

The scheme has produced a large number of very useful men for different parts of the factory, and they always have more vacancies than they can fill, covering research, drawing offices, production, planning, etc.

Wing Commander Cave-Browne-Cave, in his contribution to the last meeting, referred to three general grades of training provided by:—

(a) Certificate with Higher National Certificate and extensions.
(b) Degree of Associate Fellowship with less practical experience.
(c) Post-graduate work with experience of scientific testing and research.

He strongly supported these proposals, and also the further remarks referring to the better recognition of the Ordinary and Higher National Certificates. He felt also that the Ordinary National should be considered on a similar basis to the Matriculation and School Leaving Certificate as a qualification for entering the advanced courses of training, for example, Universities and Technical Colleges for degrees in engineering.

Mr. D. L. MARPLES (Loughborough College): He desired to make one or two comments from his personal experience on the way in which the present system of education could be improved. He was entirely in agreement with the idea of initiating further educational establishments particularly for research engineers. Many people had suggested what they thought would be a good course for engineering students without real consideration of what the student himself would like. They had to make their courses not only valuable in the sense that

the students were taught the things they had to know but also because they were "appetising." There was a particular need for collaboration with the industry and he wished to put forward four or five proposals for such collaboration, so that aeronautical engineering courses could be improved by giving the student an idea of what had been done in the past and making him more interested in the basic principles he was attempting to learn.

(1) There should be more data on the subject of design. More detailed information about the best designs, both on the structural and on the aerodynamic side, should be afforded, so that illustrative examples could be given on real aircraft and not on hypothetical ones.

(2) It should be possible for aircraft firms to supply instructors with items for test, possibly faulty constructional details or components from which test pieces could be made. Small components such as the ribs could be tested practically, and if the students knew that they came from a certain aircraft they would be the more interested.

(3) Students should be able to attend works vacational courses, principally in the drawing office rather than in the works. This was already done to some extent.

(4) The aircraft industry would do well to send representatives of particular departments, such as hydraulics, layout, etc., to the colleges and institutions where they taught aeronautics. These men should give lectures and inform the students about the latest developments in various branches of aeronautical engineering.

(5) There should be similar vacation courses for instructors so that they might make themselves more up-to-date and have contact with people actually on the job.

These were suggestions which could be readily applied to the system as it stood. The bigger schemes put forward up to date would take some time to carry through and it was necessary to give the present arrangements a real boost immediately.

A SPEAKER: Only one speech had related to the numbers of trained personnel required. He thought that they might be divided up as follows: 200 on the industrial side, 50 for research, 150 for flying (which was rather high), and 300 for maintenance. These people should pursue an average training of four years in certain branches (he did not agree that the training need be as long as five years) so that there would be 2,800 under training at any one time. It would require quite a few institutions to train them.

Educational establishments attached to works should be avoided. Care should be taken not to mix the practical and theoretical too closely. Many foremen did not like these people being taken away frequently to go and listen to someone else. If possible there should be frequent visits to the works of other firms in the industry and in allied industries.

It was more particularly after a student had left such an institution that at present he found it difficult to make progress. This was because his course had not been through a University but through a technical school. For that reason he supported Sir Melvill Jones's suggestion as to a higher research school. What was more, he felt that it would be a good thing for those who went to such a school if they were to come into the industry before going into the higher school. The 2,800 whom he had visualized as being under training at any one time would require a large number of teachers—he thought not less than 400. This at present was not easy to come by, and after the war there would be such a cry on all sides for teachers that the matter would be even more difficult.

Mr. A. E. PARNACOTT: This subject was a vast one, especially when one kept in mind the future of aviation. It was very necessary that the British Isles should take the lead in design and that the Dominions, representing altogether one-third of the area of the globe, should be able to mass-produce the very best aircraft for all services. In order to design and produce, the leading aircraft engineers had

to combine many different sides of information, especially in the spheres of physics and chemistry. For example, the aeronautical engineer had to be familiar with the use not only of all metals but with plant products such as timber. He also suggested that courses in engine design should not be limited to petrol and heavy oil engines but should include steam. Hydraulic and pneumatic work might become more important, the former for propeller drives not limited to the Fottinger practice.

He hoped that the present British system of units would not be displaced by the metric system.

Mr. P. MACARTNEY (*Associate*) : He had had some contact with a system which he had not heard mentioned at either of these meetings, namely, that which was in vogue in Sheffield, whereby the student spent six of the winter months at the University and six summer months on a full apprenticeship course in various engineering works in the city. He believed that this extended over four years and did something to meet the objections raised by speakers about night schools and about spending too much time either on practical or theoretical work to the detriment of one or the other. The Sheffield system, by employing the six-monthly period, gave a good continuity to the studies. He mentioned it for what it was worth as something which might be taken into consideration in their plans.

Mr. D. R. ADAMS (Supervisor of Training, Blackburn Aircraft) : He had come intending to make quite a number of points, but he had to some extent been forestalled by other speakers. He agreed with Professor Hill that it was extraordinary that in spite of the number of institutions capable of conferring Aeronautical Degrees or Diplomas there were so very few graduates. He believed that out of 42 such institutions only 111 graduates were produced with qualifications equal to or higher than the Higher National Certificate in Aeronautical Engineering. He agreed with Professor Hill that to some extent it was an indication that the existing facilities were not being used to the full. It worked out at something like three graduates of Higher National Certificate standard or higher per institution. The institutions were not being fully used and there must be a reason for this. He thought the reason might be found if an inspection were made of those who qualified for the ordinary National Certificate. A very large number indeed were somewhere between that standard and the standard of the Higher National Certificate. Between the two there was a falling off, naturally so, because men came to the Higher National Certificate stage at a later stage, some would be called up, and furthermore they were passing out of apprenticeship into a period when they were not so likely to receive consideration as to time off for evening classes. This was a matter for employers to consider.

He agreed with all that had been said about replacing evening classes by day instruction. It was true to say that more firms were becoming alive to that. Some of them were having day classes in addition to evening classes, or at any rate they were allowing their men to have day instruction.

The other point he wanted to mention very briefly was the importance of shop experience. He had been astonished to find at these two meetings that the degree of importance attached to shop training was distinctly secondary and in many cases had not been mentioned at all. He desired to see provision made for such training and its extreme importance more widely recognised. The firm with which he was connected made provision for apprentices to be trained as aeronautical engineers. Apprentices of this type served two years full-time in the shops under exactly the same conditions of work and discipline as the ordinary trade apprentice, with the exception that they were given experience in a number of essential shops. Their curriculum of shops was biased to some extent in accordance with the type of work the apprentice wished to specialise in later on. They were not expected to be skilled at any particular trade, but to know what was made in any particular department, and to learn the " feel " of materials and tools, and, what was of equal importance, to get to know their fellow men in the shop. He

regarded this as of extreme value. One day the erstwhile apprentice might be called upon to lead and direct those men and unless he had worked alongside them and got their point of view he was not going to be able to do that successfully. He would like to describe briefly his firm's training scheme, which followed the lines of that described by Professor Duncan at the first meeting. In the first place, boys were carefully selected before engagement and must possess a School Certificate with Credits in Mathematics and Physics.

The first two years of their training was obtained in the shops, after which they went to the University College, Hull, for two years and studied there for the Diploma in Aeronautics. The fifth and final year was devoted to working in two or more technical departments, chosen from drawing and stress offices, aerodynamics or research departments. This training scheme had been in operation for a number of years and the company was satisfied that it produced a well balanced type of aeronautical engineer, capable of tackling technical, scientific and junior administration work. His company was not only convinced of the importance of works experience but was strongly of the opinion that it should precede university of college training.

To conclude and summarise he believed that if the existing educational facilities for aeronautical engineers were used and were expanded where necessary and encouraged by the firms, a very fine educational systm was available.

The trouble had been the tendency to compartmentalism. Unless the universities, technical colleges and the firms concerned were prepared to assist each other by helpful criticism, advice and continuous co-operation, no progress would be made.

In their case, two officials of his company were members of the University College Board of Studies and a continuous contact was maintained between the university, the technical college and the company. He considered that association of this kind was essential to the aim of all concerned, which was to produce trained aeronautical engineers.

R. S. Khot, M.A., M.Sc., D.I.C. (*Graduate*): Generally speaking there are about 17 branches of science, aeronautical and otherwise, that a designer has to study. Here are some of these:—(1) Advanced physics. (2) Advanced mathematics. (3) Elements of chemistry. (4) Elements of heat and internal combustion engines. (5) Theory of structures and strength of materials. (6) Drawing and machine design. (7) Factory administration and quality control. (8) Practice of report writing. Apart from these general knowledge subjects, are the following aeronautical ones:—(9) Aerodynamics. (10) Aerodynamic design of aircraft. (11) Aeroplane construction and structures. (12) Aero engines and aero engine design. (13) Navigation and instruments and aircraft equipment. (14) Materials of aircraft construction with at least an elementary training in (15) Piloting, including gliding. (16) Meteorology. (17) Ground engineering. With an elaborate course of laboratory work in most of the experimental sciences.

This will give an idea what a strain one would expect on the brains of a youth of 16 to 20 years of age, even if he were to learn the bare fundamentals of these subjects.

Any attempt to create undergraduate university courses would necessitate the curtailment of most of these subjects to only an elementary knowledge of these.

To effect a compromise it will be found convenient to have undergraduate courses more or less based on the idea of giving an elementary training as well as a post-graduate advanced course not exceeding two years. In general the education can, therefore, be spread over a period of five years, four years being spent in acquiring a general and sufficient knowledge of most of the subjects and one year in specializing in one of the branches of the aeronautical sciences.

As such a process becomes very elaborate alternatively students of different branches of sciences and engineering like students of physics, mathematics, mechanical engineering and civil engineering already educated at institutions

suited for these purposes can be allowed to take such a post-graduate course. This will also avoid the possibility of expecting a younger brain undergoing a more strenuous training in the more advanced subjects of the aeronautical science.

Now consider the actual organisation at an institution which educates ten designers and research workers a year.

At such an institution about 20 to 30 instructors are necessary for the post-graduate course only.

An aerodynamics laboratory with a minimum of five wind tunnels and two water channels, a structures laboratory and an aero-engine testing and design laboratory comprise the necessary laboratory equipment.

To facilitate even an elementary training in ground engineering and piloting every institution will have to be affiliated to an aerodrome.

In the case of a single institution educating about 100 to 150 students the number of instructors will grow enormously and yet such an institution will be able to produce not more than 20 designers and research workers together a year.

Thus to specialise in each branch of aeronautics a student will have to spend at least 10 years of his life and such a process will give the industry a person with sufficient knowledge, although often with little interest in his work, at the end of such a long period leaving aside the necessity of starting his own life at an earlier age. This is one of the reasons why specialisation in only one or a few branches of aeronautics becomes the only answer. Designers can thus be classed into some of the following groups:—(1) Research workers in design. (2) Aero-dynamic designer. (3) Structural designer. (4) Aero engine designer. (5) Airscrew designer. (6) Administrators and project engineer. (7) Aircraft equipment designer.

At any industrial establishment they will have to be teamed up so as to suit a particular purpose.

As far as the practical experience of a student is concerned a system of vacation apprenticeship can be advocated. Alternatively it may be possible for an industrial establishment to allow these young engineers to go through their own workshops for some period while being employed as designers. This admirable practice is followed by some firms at the present, as Messrs. Vickers Supermarine.

He would, therefore, like to suggest that the Royal Aeronautical Society should invite discussions only on certain branches of the aeronautical sciences and the organisation pertaining to these. In doing this some of the following points can be borne in mind:—

(1) The necessary number of different types of designers and other personnel a year. This is very important, as in future they should avoid congestion of qualified and highly educated unemployed members of the Society.

(2) The possibility of centres of education under the direction and guidance of eminent scientists.

(3) The possibility of finding instructors to assist such men as well as the necessary equipment for such educational schemes as are built around these scientists. If possible such persons should be chosen from the younger generation who are actually engaged in either design or research work and would continue to do so while working as instructors.

When these points are taken into consideration the general trend of the discussions can be kept on some of the following aspects of aeronautical training:—(1) A research worker. (2) Designer with the specifications already mentioned. (3) Ground engineers. (4) Pilots. (5) Technicians such as draughtsmen, etc. (6) The possibility of a person getting better training when actually engaged in jobs of lesser importance, i.e., the training of personnel from the ranks. (7) Possibility of help in the line of education of the Dominions, Colonies and the dependancies in the British Commonwealth of Nations. (8) The possibility of bringing about a better understanding and co-ordination between the different scientists and the aeronautical workers of the English speaking nations, on subjects of aeronautical education.

After every discussion or sets of discussions a board or a committee should be selected by the members and this committee would incorporate such a discussion into an appropriate scheme. Such a committee should have about five to ten members.

In the above he had assumed the educational system based on centres of education in different parts of the country. Suggestions have been made towards the creation of a central institution where a set of students can be trained in an elaborate way in the various branches of the aeronautical sciences. Apart from the expenditure involved towards the establishment of such an institution, the vastness of the scheme as already pointed out, and probably the impression such a place would create on a visitor, this idea has no appeal. He was not going to detail the disadvantages of such a scheme but he would like to request the Chairman to invite a full discussion on this subject.

Group Captain G. W. WILLIAMSON (*Fellow*): In the discussion on the last occasion, he mentioned that other institutions had given prolonged consideration to this problem. The Institution of Mechanical Engineers considered a series of papers on Engineering Education and Training, one of them by Wing Commander T. R. Cave-Browne-Cave, on February 26th, 1943; and for more than a year the Institution of Electrical Engineers had been considering the same subject, this work culminating in a report and recommendations appearing in Part I of their Journal for June, 1943. The recommendations deal very largely with the problems being raised to-night; and by permission of the Institution of Electrical Engineers, a copy of them has been submitted for inclusion in the Society's Journal.

It is not therefore necessary to read them; but he may perhaps remark on those points in which they cover the problems discussed at their last meeting on this subject. In some ways, the Institution of Electrical Engineers' discussion covered a wider scope than the present one; and he would mention that the original paper by Dr. Fleming was discussed at two meetings of the institution in London and five meetings at sub-centres, so that about one hundred speakers, many of them members of other societies and institutions, had the opportunity of giving their views.

Firstly, the recommendations recognised that in any industry there will be about four grades of technicians, whose training and education will differ in quantity and time. These four grades are stated as craftsmen, foremen, student apprentices, university and post-graduate trainees.

In each class, the same problems arise: selection, a probationary training which is in itself a method of selection, methods of training thereafter, and the provision of a very much better quality of instructor than in the past.

Dealing first with the question of selection of apprentices intended for craftsmen and foremen, or even a method of producing these supervisory grades from mechanics not even graded as apprentices, a recommendation is made that the employer alone cannot necessarily find the best material, and he should be aided by a selective panel. Once the mechanic or apprentice is selected, he should undergo a prolonged probationary period, in which those young men not likely to stay the course can be weeded out.

As regards the methods of training of this class, post-war planning should produce organised schemes; and we should aim at a national standard. It is recognised that these would-be craftsmen should be trained in a special apprentice workshop instead of in the open works; and if the firm could not provide this, arrangements should be made with the local technical college. Thereafter, their practical training should be carefully organised so as to provide the maximum amount of instruction for the hours worked, and this period of their education should include part-time day release, whether or not they are attending evening classes.

There has been a tendency for instructors to be drawn from those classes who are not entirely suited to work in industry; and this process has been hastened by

the fact that the rewards of teachers compare very unfavourably with those of their colleagues working in the factories. The report goes on to say that teaching should be made more attractive; that there should be an opportunity for any instructor to return to industry as a means of refreshing himself in regard to later developments; and that anyone destined for a career in teaching should himself be instructed in pedagogy, the art of imparting information.

Dealing with those young men who would come to the firm from a university career, some similar considerations arise: once again, there should be careful selection, a probationary period, standardised methods of instruction and training, and some method by which the instructors themselves are of a higher standard.

Amongst the recommendations of the Institution of Electrical Engineers, the suggestion is made that there should be no financial barrier to a university career when the man himself is fitted for it; and that something should be done to offset the tendency in university education to produce technicians only—due regard being given to the fact that these young men must not only be scientists, but leaders of their fellows.

On one point, the institution report is closely in agreement with the suggestions made at the last meeting of the Society: it is strongly recommended that between school and the university the candidate should be given one year's experience in industry, a period which could be regarded not only as a probation, but as one which provides an opportunity for mental adjustment on the part of the student himself.

Then follows the usual three years' university career, in regard to which two recommendations are made:—

1. The shorter vacation should be devoted to tutorial classes in which the work of the previous term can be consolidated.
2. The longer vacations should be spent in obtaining actual practical experience in one or more factories.

The university course, so sandwiched with invaluable practical experience, should be followed by one year of broad practical training, before the student need decide the line he will follow for the rest of his career. During this period, his wages or salary must be such that he can regard himself as being self-supporting.

This recommendation says in effect that even the post-graduate should be allowed this one year of practical experience in which to adjust himself; and here again, correct selection and a period of probation would both be ensured if it were possible to follow this recommendation.

As regards the methods of carrying out post-graduate training the Institution of Electrical Engineers thought that post-graduate training at universities should be more fully developed; and should be supplemented by specialist courses arranged locally in the form of a series of lectures to be delivered by recognised authorities in their subject; they also recommend supplementary courses in economics, works organisation and management, and industrial and business practice. The report does not refer specifically to the need for the teaching of self-expression in the English language, which must not, however, be absent from our own deliberations.

He would like to refer briefly to a proposal made by Wing Commander T. R. Cave-Browne-Cave. His paper says:—

> The present part-time courses release students from works on one day or an equivalent period per week. This detracts greatly from the value of the student to the firm, because his job stops for one day. It is unsatisfactory for the student, because it is so short that it leaves much of the mathematical and difficult part of his college work to be done in the evening when he is tired. He is ready to tackle much of his work in the evening, but this should preferably not be that part which involves mathematics and difficult theory.
>
> If he were relieved for 50 per cent. of his day time by another student working "opposite numbers" with him in works and in college, the job in the works

would go on continuously and the student would get a much better chance with the more difficult part of his college work. This might be done in alternative weeks or half-weeks.

In the previous discussion he referred to the remarkably interesting apprentice organisation developed by Metropolitan Vickers, Ltd.; on of their senior educational advisers is Mr. Kenneth R. Evans, M.A., A.M.I.Mech.E.; and commenting upon the proposals made by Wing Commander Cave-Browne-Cave, he makes the following remarks:—

> The proposed scheme is practicable if at least two major difficulties are overcome. First, the rate of pay per workshop hour would have to be doubled, or the apprentices subsidised by the State. Alternatively, legislation to make present wages obligatory, and to compel each firm to employ a minimum proportion of apprentices, would be required. Otherwise, some firms would be handicapped in their competition for orders, both at home and abroad. Secondly, firms would have to pay wages to half of their apprentices during the alternate half of full week periods when the technical colleges were closed for the Christmas, Easter, Whitsuntide, and summer vacations. Or they would be compelled to employ twice the number of apprentices during one long and three short periods in each year, amounting in total to more than 20 per cent of the year.

If such a comment can be made in regard to proposals dealing with training in the electrical industry, it is far more necessary for the aeronautical industry to give consideration to a similar problem. As he had said previously, planning of this type of education is dependent upon government decisions; and the cost of applying such recommendations as the above to their own industry would be far greater than post-war trade could bear. If, as Sir Roy Fedden suggested, a committee is set up to examine this important problem, one of their first considerations must be the extent to which the government shall be asked for advice in regard to planning apprentice and university training, and the extent to which financial assistance can be given.

The advice should include a long term policy of recruitment. In his paper for the Institution of Mechanical Engineers, Mr. Kenneth Evans says: —

> Although it is not yet possible to determine the periods and dates of slump and boom, it must be realised that it is necessary to have an even flow of young men entering the profession. The regular flow should only be qualified by a steady increase or decrease spread over a number of years.

Only the government can provide the aeronautical industry with a statement showing the anticipated trend of trade, from which, with government assistance, calculations should be made showing the number of young men in each grade to be handled by the trade over the next ten years or so. Once these figures have been approved by the government, they should undertake a sufficient proportion of the financial liability to ensure that the education of these young men, upon which the nation's future may depend, should not be handicapped merely by a period of bad trade, either general or in a particular industry.

In their own generation they had seen this disaster fall on more than one great industry; and he referred last time to the disinclination of great firms to take apprentices at all in the period immediately following the last war. In the shipyard industry, for example, thousands of young men in Jarrow were out of work for months or years, in view of the closing of the shipyards upon which the family livelihood depended.

Supposing that advice and help can be obtained from the government, they may cast their thoughts forward to the time when it might be possible to establish an aeronautical university for post-graduate work; nothing in its constitution should prevent the attendance of senior executives in industry or instructors from other universities from attending as students for refresher courses.

Either in combination with this, or separately, they may have to organise some sort of staff college for post-graduate work on the management side; and both

these proposals would be well worthy of consideration by any committee which the Society may choose to set up.

Finally, they came to consideration of the extent to which their largest, if not their best customer, the Royal Air Force, could be induced to co-operate with them in improved maintenance of the aircraft they produced with blood and sweat.

One speaker at the last meeting spoke of the comparatively low quality of maintenance in the Royal Air Force, either in peace or war. He was regretfully compelled, after long experience, to agree with him: not so much in regard to the actual maintenance of the aircraft in service, as in regard to the lack of any long date planning which could be carried out by a genuine chief engineer and a staff of engineers with some experience other than that as pilot, even when supplemented by a very brief engineering course. Within his experience, numbers of accidents had occurred due to the lack of technical instruction of pilots even in such elementary subjects as the running up of an engine prior to take-off. But quite apart from this, the Royal Air Force is far behind the other Services in the experience training of its would-be engineers in the factories producing the highly technical equipment the Service uses.

But civilians must be careful not to interfere in matters which a fighting service may regard as its sole concern; they might, however, presume to offer co-operation and advice in regard to the future training of Royal Air Force engineer officers, assuming that they are first successful in putting their own house in order.

Finally, since it affects not only their own problems but those of the Royal Air Force, may he quote a few lines from the paper by Mr. Kenneth Evans, which he had previously referred to:—

> In August and September preceding their entry to the university, and in subsequent summer vacations, university candidates were expected to enter:—
>
> 1. Other engineering works for further manufacturing experience.
> 2. Municipal power stations and supply companies for generation and distribution experience.
> 3. They could go to sea as working supernumerary engineers on tankers and freighters, but not passenger ships.
> 4. They could go abroad to learn a language and gain experience in travel and the outlook of other peoples.
> 5. Or they could undertake any experience which had a cultural, general educational, or engineering value.

These university students have four or five summer vacations available for these experiences; and after graduation they return for a further practical training of not less than one year. Their total practical training in the works covered a period of not less than two years and two months in duration; and it is stated that heads of departments who were privileged thereafter to employ these youngsters were delighted with the results.

In their own industry they had opportunities of this type no less desirable than those available in electrical or mechanical engineering. With air lines covering the whole world, it would be odd if aeronautical students could not be given cultural and general engineering experience at least equivalent to that obtainable in any other industry.

Captain LAGOUGE (Belgian Army): As a student in Belgium, after having passed through an engineering course of five years, he had what was called a post-graduate course for a further year in order to become a specialist engineer. After taking this post-graduate course he went into the technical work, but he was sorry to say that what he learned during the post-graduate course was of very little use for the work he had to undertake. He learned much more during his first year of actual technical work than he had learned in this post-graduate course. He did not believe very much in school for specializing engineers; he believed much more in practical instruction, and he wondered whether post-graduate courses

might not be advantageously replaced by one or two years in the works solving the actual problems.

He added that others like himself were Belgian aeronautical engineers now in this country, but, being away from home, they had lost the technical point of view and had had no recent experience. He was concerned with the position when they went back eventually to Belgium and resumed their engineering work, and he wondered whether opportunity might be afforded for them to go into works in this country—he did not mean paying a one-day visit and then saying good-bye—but really going into the work and getting in touch with it. That would be a great advantage, and if anything of that kind could be arranged he for one would be very grateful.

Sub.-Lieut. R. C. ABEL, R.N.V.R. (*Associate Fellow*) (*contributed*): At the first meeting it appeared that the proposals put forward tended to fall into two categories (theoretical and practical), whereas the linking up of other branches of engineering with university degrees does not cause any neglect of practical training, even for the very numerous category which will never get near university training. On the contrary a harmonious blend is produced, in which not only is there a properly constituted ladder provided, from the bottom to the top, but this may be mounted in slow stages at any age. The University of London, which embraces schools providing evening class facilities for the apprenticed engineer, is a good example, but there are also other schemes which arrange for apprenticeship to be sandwiched into degree courses in a variety of ways.

University training, quite apart from the class of secondary education the student may have had, trains the judgment for new developments, by building the specialised training on a preliminary very wide basis, which may be common to many different Faculties of a University. Consequently the basic requirement for the character of the University is that all its Faculties should cover a wide enough ground to gain recognition of its "universality."

Now the subjects which can be included under "Aeronautics" in the honest sense of being specially characterised by that association, do in fact cover a universal field, for example:—

Fluid Mechanics.
Vibration.
New Materials.
Motive Power.
Medical.
- Parachute Jumping.
- High Altitude Flying.
- Violent Manœuvres.
- Travel Quarantine.

Surveying.
International Law with special reference to the right of "Innocent Passage" over territories.
Economics.
- Manufacture.
- Transport.
- Mercantile Insurance.
  - Sailing ships.
  - Powered ships.
  - Flying ships.

There are two types of University in this country, with the Colleges close together, as at Cambridge, or with a hetrogeneous arrangement of scattered Colleges, as in London. It is also possible to have an even more widely scattered Federation of University Colleges and Polytechnics, and the suggestion made here consists of three points.

(1) Arrangements between polytechnics and aircraft factories of all kinds, either for evening class co-operation, or sandwiched whole-time courses, or some other arrangement copied from other branches of engineering.

(2) Formation of many more schools, such as the De Havilland Technical School seems to have developed into, with orthodox constitutions.

(3) Federation of all this about a post-graduate research centre, not forgetting the possible development of Aero Research, Ltd., at Duxford, into a suitably constituted college.

Two vital problems arise from this proposal, which are made rather knotty by the fact that their solutions tend to conflict, i.e. full recognition by other Universities of a proper University status, and the problem of a generation of aeronautical engineers who have attained competence by recognising, not only the characteristic "differentness" of this new science, but also the shrewdness of sacrificing a degree course in some unsuitable Faculty, for the sake of unfettered "blossoming" in aeronautics—these will demand degrees from such a new University, without anything more than a testing course, as distinct from any honorary degrees that may be conferred.

Finally the formation of various societies which form an important part of University life, and are quite convenient even with the scattered Colleges of London, will not be so easy for the nation-wide federation such as is suggested for the Aeronautical University, but may well be achieved by an ambitious programme of regional meetings organised by the Students' and Graduates' Section of the Royal Aeronautical Society, together with a system for touring the different kinds of Colleges during the first part of a degree course. Aeronautics has a message for civilisation and no plan should be considered too ambitious at such a time as this.

N. S. Muir (*Associate Fellow*) (*contributed*): Arising from the proposed Reform in Education recently announced by the Minister of Education it is clear that technical education will undoubtedly be a large part of the general scheme. In this branch there must be envisaged a considerable emphasis on the science of aeronautics.

The personal views of Sir Melvill Jones and other eminent authorities who have attended official discussions and public meetings, following the recommendations of the Fedden Mission arising from a study of the growth and present position of aeronautical education in America, have supported this aspect and it appears that the Government, the Aeronautical Research Committee and the industry have now indicated their views in support of the founding of an aeronautical education centre of a national character.

A National School for Aeronautics should provide training over the whole field of research, technical development and production. It should thus have both an academic and industrial appeal. This is important because there are normally two types of students:—

(a) Those of school certificate or matriculation standard normally entering industry at about 16 years of age who wish to train in some branch of aeronautical engineering under virtually a trade apprentice type of scheme, and

(b) The graduates of more mature years who also wish to specialise in some branch of aeronautics.

It is clear that usually some candidates from type (a) will eventually become type (b).

To build and equip a National School to train such personnel on the widest possible scale in both theory and practice would involve the expenditure of millions of pounds to provide an appropriate site complete with an airfield, laboratories and teaching facilities in all phases of the subject. Such an institution would, however, still fall short of the ideal because at the end of the training course the individual would not have acquired any of that breadth of experience or vision which at present necessitates some years spent in practical contact with the industry.

Many contributors to the recent discussions held under the auspices of the Royal Aeronautical Society emphasised the need but did not suggest the means.

The purpose of this memorandum is to focus attention in this respect and to draw attention to the unique position offered at Farnborough by the Royal Aircraft Establishment as the site for the National School. On first consideration this suggestion may seem odd because the R.A.E. is a Government Research Establishment—but the proposal hinges on just this very fact.

There is no other place in the Empire possessing such a concentration of facilities for the teaching and practice of aeronautical science—and the scheme could be arranged so that the establishment could fulfil both functions, namely that of a Government Research Establishment and that of an educational institution catering for students of the trade apprentice standard right up to and including the post-graduate. Entrants would normally have to be British subjects or otherwise officially approved. There is already an R.A.E. trade apprentices scheme which plays a very useful but lamentably small part in the training of aeronautical engineers. This scheme could be considerably augmented within the framework of this proposed programme and could link up with the similar schools run by many industrial companies.

A post-graduate scheme could be instituted, using as teachers (part-time in the first instance) the present university professors and staffs implemented by suitable R.A.E. permanent staff, which would operate on conventional university lines on a scale commensurate with the facilities available in the establishment.

It has already been stated that last year American institutions directed into industry some 1,400 aeronautical graduates, and there would appear to be no reason why a National School at the R.A.E. should not ultimately train at least a quarter of this number of post-graduates per year.

The basic idea is that after instituting the theoretical side of the syllabus it only requires the practical and laboratory work to be organised and co-ordinated with it. The actual official work now proceeding and the work of the future will provide such laboratory training and experience of the application of theory ranging from the drawing-office to the full scale flight test in a manner quite unique in the history of technical education, and which could never be achieved so readily in any completely new institution or combination of existing universities.

To attempt to do so elsewhere would, as already indicated, involve much outlay, time and labour and the result would ideally be merely a replica R.A.E. but without the actual handling of official civil and service development work which provides the unique background to such training.

It is suggested that a much smaller amount of money would suffice to provide the teaching facilities and other university features at the R.A.E. than elsewhere. The students, who in the first few years would comprise new entrants and some proportion of existing staff, would be treated as members of R.A.E. departments.

This idea works well in many American universities such as for example the Californian Institute of Technology where the students themselves are paid for running the wind tunnel some 18 hours a day, in shifts to allow for normal study, on the projects and reasearches contracted for by the government and the aircraft firms.

Full practical training obtained automatically is thus possible in a unique way:

(1) By the "university" organisation and atmosphere in the teaching branch.

(2) By the fact that the personnel under training are actually employed at other times on the normal work of the R.A.E. and paid according to some scale or scheme which would take into account the fact that they are also receiving specialised training.

Full use would be made of the airfield after normal working hours in the teaching of flying and other co-ordinated activities and thus would save expenditure on a new site or on the modification of some other existing airfield of which many no doubt will become redundant after the war. Redundancy

should not be made a basic argument for the laying down of a new school at such an airfield where the necessary equipment would still have to be installed at considerable cost in time and material.

It is suggested that the use of a reconstituted R.A.E. as the National School in addition to its present function as a Government Research Establishment will enhance its reputation internationally and would provide a most excellent source of skilled aeronautical engineers and scientists. Some of these could, each year, probably continue to be employed on the permanent staff and the remainder can be absorbed in the Empire's aeronautical industry.

An important result of the above proposal would be that the official work of the R.A.E. would be expedited by virtue of a large number of keen student assistants that will be available, part-time during the academic year and full-time (less normal official leave) for the rest of each year.

N. A. WHITE (Hon. Secretary, Luton Branch) (*contributed*): In considering any scheme or proposed scheme for the education of aircraft engineers the Society should give due thought to the possible position of the aeronautical industry after the war, as it would not seem possible that it would be able to support then, anything like the number of technicians that it employs in wartime. As already stated by Sir Roy Fedden the American system of aeronautical training should not be looked upon as a perfect example, but it should be considered from all angles in order that the scheme now being drafted can take every advantage of the work done in America. The greatest care should be taken to ensure that the correct background and right type of training of a high standard be given and thereby prevent a mass produced pupil which the M.A.P. mission led by Sir Roy Fedden apparently found in the U.S.A. He would put forward the suggestion that University graduates be given practical training in works during their vacations and so help to bridge the gap which now exists between the theoretical graduate and the practical engineer.

The training should be as broad as possible up to at least the Higher National Certificate stage, because unless this is so an engineer employed in such a quick changing industry as their own may find himself inadequately trained within a few years. Sir Melville Jones has already emphasised the necessity for one central university, as the elaborate apparatus required for post-graduate training would be extensive and a large number of specialized teachers would be required, however few students there were, but nevertheless a certain amount of more elementary aeronautical training could be given at various educational institutions throughout the country. By doing this the more practical engineer who requires to know the principles of aeronautics as apart from the highly specialised technical knowledge required by the research worker would be provided for. He would personally like to see the existing arrangements in this direction very much enlarged.

A number of speakers had urged that post-graduate courses should be concerned with the engineering production aspect of aeronautical work, but as the methods and processes used in the aeronautical industry are similar and in some cases identical to those used in other industries it would seem advisable that this branch of the training should not be delegated to purely an Aeronautical University, but more correctly to a course selected by a "Council of Engineering Institutions." This would seem advisable, as methods and processes of various industries could then be interchanged to the advantage of all concerned by calling upon all industries to provide personnel to give lectures.

One main feature which does not seem to have been covered is the cost of these proposed post-graduate courses. It is a well known fact that university training is only obtainable by those having good financial means because even though a limited number of scholarships are available they do not cover the expenses involved. It has already been stated by Sir Frederick Handley-Page that the person who learns engineering through the hard school of life in the workshops of a firm and eventually obtains a General Engineering Degree by part-time study

is the better engineer, because the other individual having attended a university and knowing full well that whether or not he obtained a degree, a good job awaited him, he did not become as well educated finally as the person who had to *earn* his living. It would seem that a Government grant would be necessary if the scheme now under consideration is to be available to all who have the ability whether or not they have the financial means. By these remarks he did not wish to insinuate that the training should be free, but he would like to see the number and value of engineering scholarships increased.

He agreed emphatically with Mr. R. Hadekel on the " Status of an Engineer," and he thought everything it is possible to do in this direction should be done.

Finally, the aeronautical branch of engineering has always been outstanding for its determined attitude in carrying out experiments, and it should continue this policy with the training of its future employees.

Flight Lieut. R. G. SIMMONS (*Associate Fellow*) (*contributed*) : When he chose aeronautics on leaving school it was because it was " the coming thing." He had no specific course charted for him by the headmaster as he would have done had he chosen commerce, or one of the other professions, and in this he fancied he was no exception. It seemed that as an apprentice to one of the aircraft firms he could only learn a very specialised trade in the industry, e.g. one engine or one type of airframe construction, and that in consequence his career would be entirely dependent upon the success or failure of that firm. Alternatively, as an apprentice to the Royal Air Force he could get quite a good general knowledge of aeronautics, but with only limited prospects of its application and his own advancement. As one who chose this latter course, intending to transfer to civil aviation at the end of his twelve years' service, he might add that he was later confounded by the realisation that very few, if any, of the qualifications and diplomas issued by the Royal Air Force were directly recognised as such in civil aviation, and vice-versa.

Judging by what has already been said at the meeting held on June 25th, 1943, it would appear that the situation to-day has not materially altered in these respects from what it was thirteen years ago. It therefore seemed to him that the Royal Aeronautical Society could perform a useful service in the cause of aviation if it were to submit a memorandum to the Minister of Education showing :—

(a) The broad divisions into which the whole field of aeronautics may be divided.

(b) The prospects of future candidates in each division, giving possible careers, and showing the proportion of posts normally to be filled in each grade of the divisions.

(c) The suggested educational standards, in terms of present day school and university standards, required in each grade in each division.

(d) Where present day standards of education are grossly inadequate, an analysis of their shortcomings and recommendations for their improvement.

Anybody who has had experience as a Unit Censor will endorse the complaints made about the general lack of ability in self-expression and he felt that in many cases lack of ability in leadership is the inevitable result of this. However, this is an indictment of the educational system as a whole which if endorsed by the Royal Aeronautical Society could be conveyed with appropriate recommendations to the proper authority. He considered that this lack of ability in self-expression and leadership is directly responsible for the dearth of good teachers and instructors to be found in the lower grades. Far too often a man is left to learn in the hard school of experience with consequent waste of time, energy and material.

Presumably the requirements in man-power for the immediate post-war period will be met by the demobilisation of the shadow factories and the three Services. Aeronautical training centres, such as have already been outlined, must therefore be established and be in reasonable working order before this period is upon them.

In conclusion, he would stress that a survey of the whole field of aeronautics is an essential preliminary to any long term planning which is to put their house in order.

RESOLUTION.

THE CHAIRMAN: The point had been reached in the discussion when a resolution might be usefully put forward. He did not want anything elaborate, but certain points of view which had been expressed might perhaps be combined in some form of resolution which would reflect the general feeling of the meeting.

Mr. M. LANGLEY: He proposed the following:—

(1) That the Reports of these two meetings be conveyed to the Council of the Royal Aeronautical Society with a recommendation that it endeavours to arrange for a committee to be formed to draw up a plan for the training of aeronautical engineers of all grades, bearing in mind the qualitative and quantitative requirements of the industry.

(2) That the plan is to be designed in the first place to suit the particular requirements of the United Kingdom but co-ordinated into a Commonwealth scheme as soon as convenient, and the Committee to recommend what steps should be taken to this end.

(3) That the plan be co-ordinated with similar schemes at present being developed in other branches of engineering, particularly those of the Institution of Mechanical Engineers and the Institution of Electrical Engineers.

(4) That the Committee should include representatives of the Ministry of Labour, the Air Ministry, the Ministry of Aircraft Production, the aircraft industry, and the Board of Education, and that it should collaborate with the Board of Education in consultation with the aircraft industry as suggested in Paragraph 84 of the recently issued White Paper on Educational Reconstruction.

Prof. F. T. HILL: He considered that something ought to be added about the Society's own scheme.

The CHAIRMAN: A clause might be added to the effect that, in considering this matter the Society should review their 1938 scheme for apprentices and theoretical training.

Prof. HILL: That would cover his point.

Group-Captain G. W. WILLIAMSON: The Society would do well to visualize what it was intended to do concerning the people returning to industry from the war before it considered what it was going to do about people who had never been in the industry before.

The CHAIRMAN: That might furnish material for another clause.

A MEMBER: One point which might be added to the clause dealing with collaboration with other bodies is that collaboration should also take place with the Institution of Automobile Engineers. There were certain aspects of aero engine design which interested them.

The CHAIRMAN: It might be wiser to generalize that paragraph and speak of "other engineering institutions."

Mr. LANGLEY: He agreed to that amendment of his resolution.

Group-Captain WILLIAMSON: Mr. Langley had used the phrase "qualitative and quantitative requirements of the industry" and it was following this that some reference should be made about taking account of personnel returning from military service.

Mr. LANGLEY: He agreed to this modification also.

A STUDENT MEMBER: He suggested that one of the most interested parties was the students themselves. Difficulty might be found in discovering a representative body of students, but the student point of view should be consulted.

The CHAIRMAN: The Society had a Students' and Graduates' Section, and while one could not quite foresee how this matter would be organized he assumed that the Committee could take evidence from one or two students appointed by their fellows from that section.

A MEMBER: Clause (3) of the resolution might be extended to the effect that evidence be taken as to conditions not only in this country but throughout the world. He had in mind the post-graduate schools in the United States Universities. There were also two specialized branches of education, one of them for the specialist training of research scientists, in the Soviet Union. This experience might be studied.

The CHAIRMAN: Clause (3) of the resolution deals with the co-ordination of national schemes. What the last speaker suggested was that in planning they should take into account what was being done elsewhere. That would be best covered by a separate clause somewhat to the following effect:—

That the Committee should give due consideration to educational systems in other countries, particularly in the United States and the Soviet Union.

He felt that the set of recommendations now before the meeting was, if not absolutely complete, sufficient to indicate the trend of their thinking and to start matters along the right lines. He hoped that the Council would be able to act on the amended resolution. He then put the resolution as expanded and modified in the following form:—

(1) That the Reports of these two meetings be conveyed to the Council of the Royal Aeronautical Society with the recommendation that it endeavours to arrange for a committee to be formed to draw up a plan for the training of aeronautical engineers of all kinds, bearing in mind the qualitative and quantitative requirements of the industry, and first taking account of personnel returning from military service.

(2) That the plan is to be designed in the first place to suit the particular requirements of the United Kingdom, but co-ordinated into a Commonwealth scheme as soon as convenient, and the Committee to recommend what steps should be taken to this end.

(3) That the plan be co-ordinated with similar schemes at present being developed in other branches of engineering by educational establishments and by engineering institutions.

(4) That the Committee should include representatives of the Ministry of Labour, the Air Ministry, the Ministry of Aircraft Production, the aircraft industry, students, and the Board of Education, and that it should collaborate with the Board of Education in consultation with the aircraft industry as suggested in paragraph 84 of the recently issued White Paper on Educational Reconstruction.

(5) That the Committee should closely consider the Royal Aeronautical Society's 1937 educational scheme.

(6) That the Committee should give due consideration to the educational systems in other countries, particularly in the United States and the Soviet Union.

This amended resolution was put to the meeting and carried without dissent.

CORRESPONDENCE

(The following is a copy of a letter to the " Staffordshire Sentinel " which has also been sent to the Editor of the Journal. It concerns a proposal to raise a sum of money to found a Youth Hostel in the Stoke-on-Trent area.)

Sir,—As a Kerr Stuart apprentice, and one who helped to build the first and subsequent Battle of Britain Spitfires, and also helped to repair and doctor them after being in action, I would like to express my views on a memorial to R. J. Mitchell, through the " Sentinel."

First, the memorial should not be parochial, municipal, or even national, but universal, and of such a character that all the countries and people of the civilized world would use it. The winning of the Battle of Britain saved the civilized world, and the Spitfire aircraft flown by the cream of the youth of Britain and the Empire had a large share in the victory.

Second, the memorial should perpetuate and keep alive the foresight, realism and perseverance of R.J. and the men who flew and fought in his creation.

These two points seem to be perfectly welded in a Mitchell Memorial College, to attend which would be the ambition of every young aircraft designer and visionary. A few acres of the ground over which the Spitfires and their pilots proved R.J.'s genius to the world would be a fitting site for the memorial. The honour of the buildings and equipment should be that of the aircraft industry of the Allies.

Entrance to the college should be by a special universal examination and perfectly free of any monetary liability to a successful candidate, in fact the college would be open to the poorest or richest boy who showed promise of genius or greatness in the science of making the air safe for mankind to use, of which R.J. was a pioneer. . The cost of this should be the responsibility of the people in grateful memory of a genius who, in may belief, gave his life to help them. The city which is justly proud of being his birthplace and cradle can honour his memory by finding and nursing other fellow citizens to carry on for him.

Yours faithfully,

A. AINLEY.

EXTRACT FROM THE REPORT OF THE EDUCATION AND TRAINING AND PERSONNEL SUB-COMMITTEE OF THE INSTITUTE OF ELECTRICAL ENGINEERS.

Recommendations.

(1) Craftsmen and Foremen.

There is general agreement on the need for measures which will lead to improvement in the status of the craftsman. To this end the following recommendations are made:—

(a) That more care should be exercised in the selection of entrants to craft training courses. This should be the responsibility of panels representing wider interests and experience than those of the employer alone. (4.1.)

(b) That there should be a probationary period for all craft apprentices during which provision would be made for transfer to more suitable employment where necessary. (4.3.2.)

(c) That the apprenticeship should commence with a period in a special apprentice workshop where the elements of the craft would be acquired under the guidance of experienced instructors. Where possible these workshops should be a part of the industrial organization, but co-operation of the local technical colleges will be necessary where this is impracticable. (4.3.2.)

(d) That subsequent practical training should be organized and that definite responsibility for the training course should be accepted by each employer. (4.3.2.)

(e) That part-time day release should be granted for general education and for vocational instruction. (4.2.2.)

(f) That the combination of workshop and classroom instruction should be organized on nationally recognized lines and that a Craftsman Certificate be instituted. (4.3.1.)

(g) That subsequent part-time courses should be provided leading to certification for foremanship. (4.3.3.)

(h) That the school-leaving age should be raised and that the full-time education received up to this age and the part-time education received subsequently should both be planned on as broad a basis as possible. Thus every facility would be afforded for development, not only in the craft or trade but also in the best use of leisure, and transfer to other types of work would be simplified for the man who so desires. (4.3.1.)

(2) Student Apprentices.

This title is intended to cover those whose practical training and technical education are combined on a part-time basis, who will become draughtsmen, designers, etc., and may attain some of the highest executive positions.

It is recommended:—

(a) That organized schemes of practical training should be instituted, or participated in, by all employers of student apprentices and that recognized national standards should be established. (4.2.4.)

(b) That part-time day release for study, both general and technical, should be compulsory and that this release should not be for less than one full day per week. (4.2.2.)

(c) That attention to technical matters at the expense of the study of broad scientific principles should not be permitted in the early stages of the course. (4.2.3.)

(d) That some part-time evening instruction should also be available, but that this should not be made compulsory. (4.2.2.)

(e) That the present schemes of Ordinary and Higher National Certificates should be continued and developed and should form an integral part of student apprenticeship. (4.2.2.)

(f) That consideration should be given to making teaching in technical schools, institutes and colleges more attractive as a profession. (4.4.2.)

(g) That the facilities which are available for technical teachers to return to industry for short periods, to renew their industrial experience, should be extended. (4.4.2.)

(h) That technical teachers should receive instruction in the art of teaching. (4.4.2.)

(3) University Trainees.

It is recommended:—

(a) That full-time university courses should be made available to anyone who has the ability to obtain full benefit from them. There must be no financial barrier to entry. Schemes similar to the present State Bursary scheme should be implemented after the war, provision being made for increased transfer from National Certificate to university courses. (4.2.1.)

(b) That university engineering schools should cease to treat all students as potential high-grade scientific or technical workers. Those who are not, should receive instruction in economics, law and social science in place of the more advanced technical instruction. It is the duty of the university to equip men for leadership and not merely to impart advanced technical and scientific knowledge. (4.2.3.)

(c) That university engineering students should devote part of the two shorter vacation periods to tutorial classes and part of the longer vacation period to the acquisition of practical experience. (4.2.3.)

(d) That a period of the order of one year should be spent in gaining experience of industry before proceeding from school to the university. (4.2.1.)

(e) That all university engineering graduates should be given a course of practical training of a broad character. (4.2.5.)

(4) "Post-advanced" Students.

The professional engineer must acquire specialized knowledge of the branch of engineering in which he is engaged, and the university graduate must acquire practical experience before he is able to apply his academic knowledge usefully.

It is recommended:—

(a) That post-graduate work at universities should be further developed. (4.2.3.)

(b) That "post-advanced" courses of lectures by recognized authorities should be provided locally, on specialized branches of engineering practice. (4.2.5.)

(c) That technical colleges should extend the provision of "post-advanced" course in such subjects as economics, workshop organization and management, industrial management, business practice. These and similar subjects should be studied when the student is sufficiently mature to appreciate them and is likely to be able to make use of them. This is particularly important in the training of men who have been selected as potential executives. Such men should also be afforded opportunities of acquiring experience in administration. (4.2.5.)

REVIEWS.

Air Transport and Civil Aviation Year Book, 1943.
Todd Publishing Co., London. 1943. 10/6.

Section 1 of this book consists of a series of articles on Civil Aviation; Section 2, Memoranda and Statements of Policy; Section 3, Air Transport Committees; Section 4, The Principal Air Transport Companies; Section 5, Air Transport Companies of the World; Section 6, Alphabetical Air Guide; and Section 7, Distances Between Airports and Town Centres.

In the Foreword it is said, "The present work is an attempt to gather into one volume the available relevant information, together with representative and authoritative views on the subject."

Under any other title this book would have been better at the present time. It labours under the fact that much information which would have added to its value as a Year Book may not be published, just that information one expects to see in a Year Book. Most of the material in the first section is reprinted from other sources. The second section gives the vague general non-committal political statement of the Government by Sir Archibald Sinclair and Viscount Cranbourne, two pages of nine times nothing, and is followed by the report on American Air Transport, prepared by the United States Office of War Information. Following these is the report of the General Council of British Shipping and one by North Eastern Airways.

Section 3 gives the report of the Lamplugh Committee and the Joint Air Transport Committee, both of them excellent.

There is no need to comment on the remaining sections of the book. To whom it will appeal it is difficult to say. Most of those in aviation are already well acquainted with its contents, and to those outside the arrangement is such that it will be difficult to convince them of the parlous state in which British aviation will find itself if left in the hands of those very people who failed to produce the goods before the war.

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This specification details requirements for two grades of plywood, (A) to be used only where it is necessary for design reasons and for bent parts, and (B) for three-ply not covered by A and for multi-ply.

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BASIC CALCULATIONS FOR R.A.F. GROUND DUTIES.

A. E. Druett, B.Sc., A.M.I.Mech.E. Sir Isaac Pitman and Sons, Ltd. 1943. 3/6 net.

This book is mainly intended for airmen engaged in the radio, wireless and electrical trades in the Royal Air Force. It is also of use to cadets of the Air Training Corps who are training for any of the corresponding ground duties.

The contents cover the necessary arithmetic and geometry required and each chapter is followed by a number of examples. These examples are excellently chosen and apply directly to the electrical trades, so avoiding the academic dry-as-dust questions which have made so many text books in the past works of labour instead of interest. It is refreshing, indeed, to see the steady trend in mathematical text books towards giving examples which are practical.

For those students who have little or no opportunity of consulting teachers all the examples are fully worked out at the end of the book.

A book to be recommended.

ELEMENTARY HANDBOOK OF AIRCRAFT ENGINES.

A. W. Judge. Chapman and Hall, Ltd. 12/6 net. 1943.

Mr. Judge is well-known for numerous books on engines and this, his latest book, should prove of welcome assistance to all those entering the aircraft industry who wish to obtain a good working acquaintance of the engines used in aircraft.

Here, in simple straightforward language, is explained the working of the four-cycle engine, its combustion, cooling, lubrication, ignition, supercharging, testing and maintenance, as well as descriptive details of engine components. The book is extremely well illustrated with photographs and diagrams and may be thoroughly recommended as a text book on the subject which fills a gap between the elementary (too much so, generally) and the more advanced text books. It is a book that will certainly be of value to aircraft mechanics, R.A.F. personnel and A.T.C. personnel.

THE SKY'S THE LIMIT. THE STORY OF BEAVERBROOK AT M.A.P.

David Farrar. Hutchinson & Co., Ltd., 1943. 6/- net.

"This," says the notice on the cover, "is a breathless account of his breathless year at the M.A.P., and a notable tribute to a great man of genius, drive and foresight."

The Oxford English dictionary defines breathless as "lifeless; panting; holding the breath; unstirred by wind."

The book under review cannot be said to be "lifeless," but one is not sure that the author wrote it "unstirred by wind."

It is a vivid account, certainly, of a great personality, but books by hero-worshippers give only one picture of their hero. Attention is drawn to the fine pigments, the wonderful gold frame, the exquisite brush work. But the thing which matters is whether it is an accurate portrait of the man.

The time is not ripe to give the answer, as it is not the time, to consider, when "block-busters" are falling, whether they are "big bombs, fat bombs,

thin bombs, *beautiful* bombs," to quote Lord Beaverbrook. But if you can hold your breath long enough the book should be read.

It is a pity that the title, chosen from a phrase used by Lord Beaverbrook, should be that of a less breathless book by J. M. Spaight.

FROM MANY ANGLES.

Major-General The Right Hon. Sir Frederick Sykes, G.C.S.I., G.C.I.E., G.B.E., K.C.B., C.M.G., M.P. George Harrap & Co., Ltd., 1943. 25/- net.

This is an important historical record. Sir Frederick Sykes has had a widely varied life, one which is given to very few, and has been over many years in close contact with most of the leading personalities who have helped to shape or misshape the things to come.

To the aeronautical enthusiast the most interesting and valuable parts of this autobiography are those dealing with the birth and development of the Royal Air Force. The author was one of those pioneers who lived in the days when designers of aeroplanes were threatened with prosecution for their suicidal attempts to learn to fly.

At the British manœuvres of 1910, relates the author, Captain Bertram Dickson, who had learned to fly in France, persuaded the authorities to allow him to go up in a biplane of the Henri Farman type. Permission was granted with reluctance. A complaint was made that the aeroplane might frighten the troop horses.

The opposition by senior officers to air experiments, indeed, almost amounted to mania. To quote, "General Nicholson, the chief of the Imperial General Staff, was of the opinion that aviation was a useless and expensive fad advocated by a few cranks whose ideas were unworthy of attention. One of his colleagues expressed the opinion that there were too many complications in modern war already, and we would only get into a worse tangle by adding to them."

In spite of opposition, however, an Air Battalion was formed under an Army Order of February, 1911. Headquarters and No. 1 (Airship) Company were established at Farnborough, and No. 2 (Aeroplane) Company at Larkhill, on Salisbury Plain. That year Sir Frederick Sykes flew as an observer, to spot a small Army force, on a Henri Farman of the box kite pattern, fitted with a 50 h.p. Gnome engine. It was the first reconnaissance of its kind.

From the observer's point of view it was an extremely uncomfortable reconnaissance. The flight lasted twenty minutes at 1,000 feet, and the hidden Army force was quickly found and reported. In June of that year the author took his pilot's certificate, one of the first half-dozen British officers to qualify.

In 1912 a sub-committee of the Committee of Imperial Defence under Colonel J. E. B. Seeley was formed and out of its report came the Royal Flying Corps, "an aeronautical service for naval and military purposes," the actual establishment being made in May, 1912. The author was on the committee and was instructed to recruit, train and command the Military Wing of the new corps, of which Commander Samson, R.N., was in charge of the Naval Wing, and Captain Paine, R.N. of the Central Flying School. Britain's air arm was in being.

The inertia of the human mind after long training and experience in any given walk of life is sometimes beyond belief to those who have kept their minds free. In July, 1914, a month before the outbreak of war, Haig told his officers: "I hope none of you gentlemen is so foolish as to think that aeroplanes will be usefully employed for reconnaissance purposes in war. There is only one way for a commander to get information of reconnaissance, and that is by the use of cavalry." Even in 1926, Haig, in a public speech, emphasized his view that the aeroplane was only an auxiliary to the man and the horse.

On the outbreak of war the R.F.C. put into the field 105 officers, 775 other ranks, 63 aeroplanes, and 95 mechanised transport vehicles! Almost every machine fit for active service in France went there, and most of the pilots had never crossed the sea in an aeroplane before.

The history of the fighting in France and elsewhere is told in the following chapters, the appointment of the author as chief of the Air Staff and the formation of the Royal Air Force. In 1919 the author was appointed Controller-General of Civil Aviation, a post he resigned in 1922 to enter Parliament and ultimately to be appointed Governor of Bombay.

Sir Frederick Sykes' book is one which requires careful reading and one which it is necessary to read to avoid, if possible, the errors which held back the proper development of aircraft in this country for so long. It is hoped that the Government will, as the result of the experiences of this war, come down heavily on the side of research and development for all forms of aviation. Without energetic research and development this country will take a second place in world aviation.

CORRESPONDENCE

To the Editor of the JOURNAL OF THE ROYAL AERONAUTICAL SOCIETY.

Sir,—May I enter a strong protest against the title,

"*Astronomical Navigation Without Mathematics*,"

of Lieut.-Colonel Mieville's otherwise quite excellent article which appeared in your August number?

The title is, I suggest, both untrue in fact and misleading in implication.

Navigation without mathematics is just impossible. Whether the mathematics is arithmetic (calculation), algebra (formulæ), or geometry (star charts) is a matter of convenience, coupled with the achievement of accuracy adequate to the purpose in hand. Surely, too, much mathematics lies behind the design and drawing of the star charts, in which the expert has "potted" his knowledge so as to allow the tyro to make use of it.

But the implication—that mathematics is a bad thing, to be avoided like the plague, and that it is so difficult that only a few can do anything with it—is surely out-of-date, even if it could ever have been explicitly maintained. If a job can be done more expeditiously and efficiently with mathematics than without, then let the mathematics be learned in the same way that the use of any other tool or machine is learned. In my experience, it is rare to find a student who is unable to master the mathematics of a subject in which he is *interested*, when he sees the meaning and use of the symbols and their connection with the real things in which his interest lies. Simplify, condense—"pot"—by all means, but accept what mathematics can do—and especially what *only* mathematics can do—frankly and gratefully!

Yours truly,

W. G. BICKLEY.

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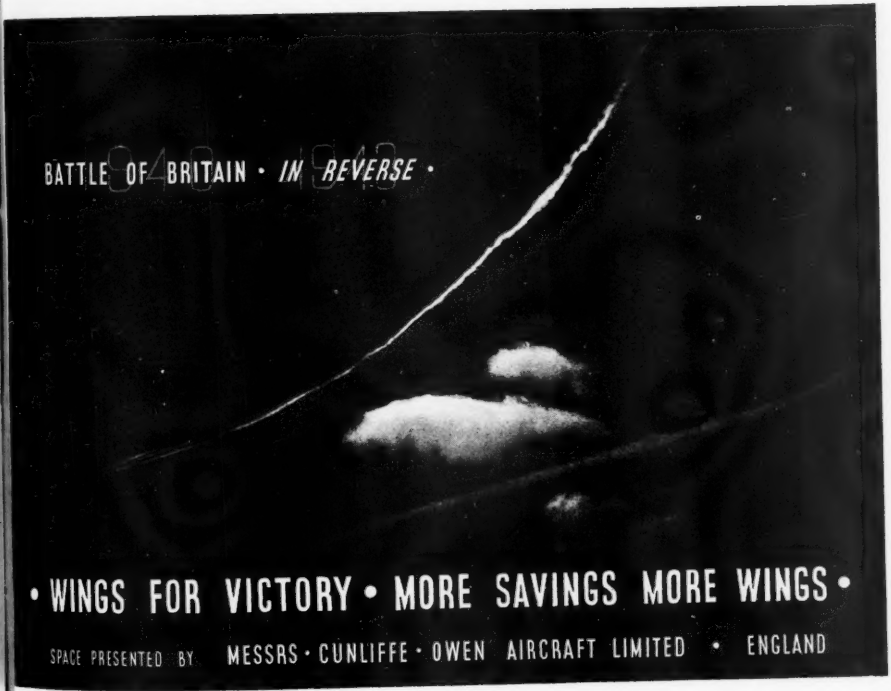
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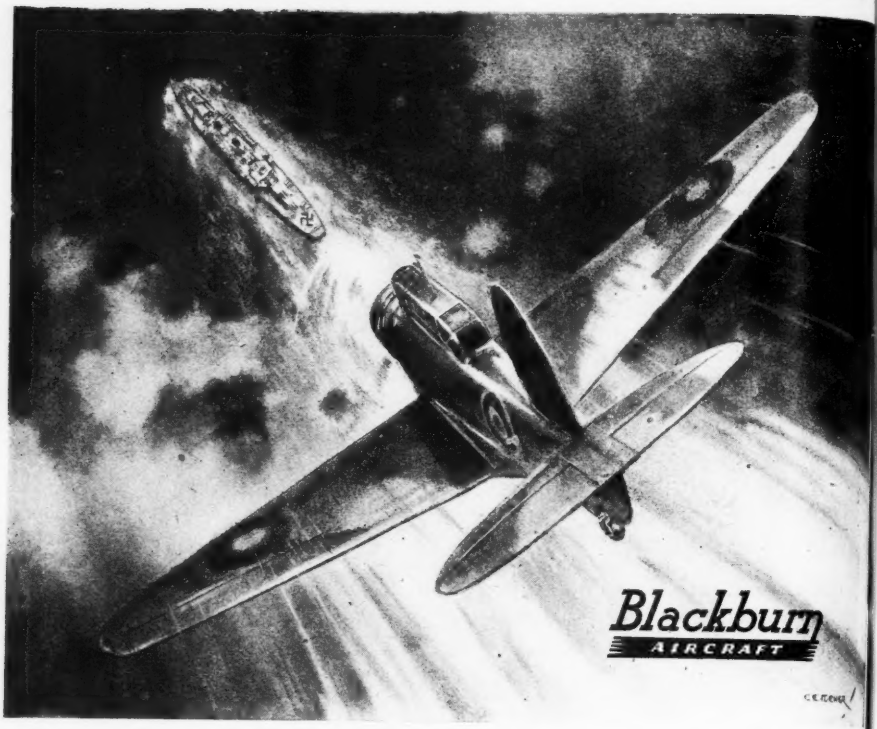

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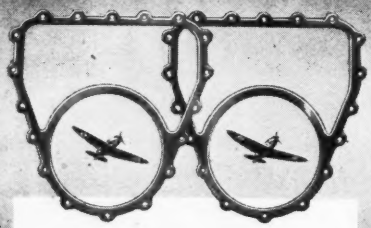

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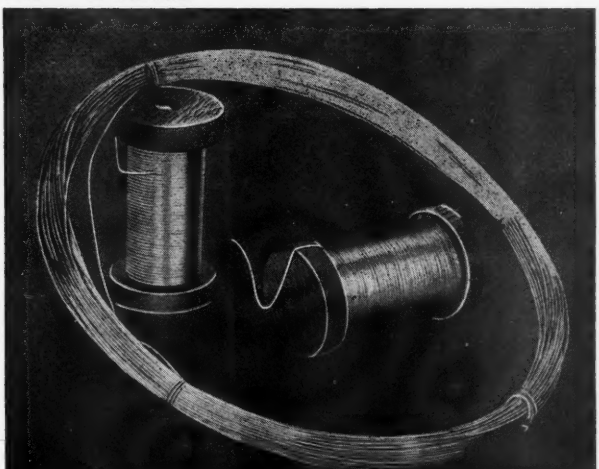

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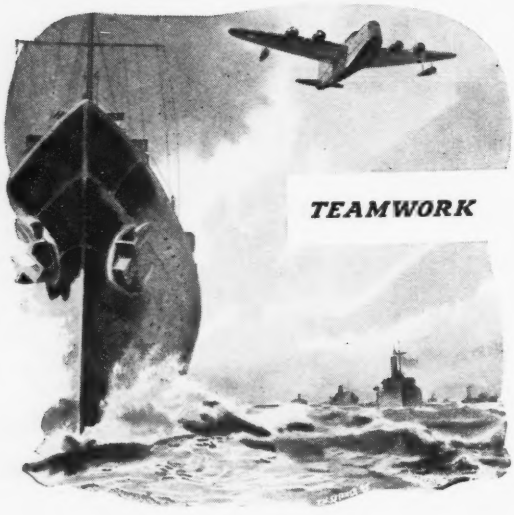

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